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- Welcomes articles in Occupational Safety and Health related fields.
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CONFORMITY TO OCCUPATIONAL SAFETY AND HEALTH REGULATIONS IN SMALL AND MEDIUM ENTERPRISES

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Abstract

Regulation on occupational safety and health in Malaysia had evolved from the prescriptive Factory and Machinery Act (1967) to a self-regulated Occupational Safety and Health Act (1994). However, from the authors’ observation the high standards of occupational safety and health culture that surpass the legal requirement were not widely practiced by small and medium enterprises (SMEs). The two main objectives of this study are: first, to identify and determine the level of conformity; and second, to investigate the reasons of nonconformity to Occupational Safety and Health Act (1994) regulation in SMEs involved the chemical industry sub-sectors. The survey questionnaire was distributed to 150 SMEs in chemical industry sub-sectors. Forty one of the survey questionnaires were completed and returned, giving a response rate of 27.3% for the survey. The survey results revealed that an overwhelming majority (92.7%) of the respondents from SMEs are likely not conforming to the basic requirement of Occupational Safety and Health Act (1994). In addition to this, the survey also found that only 3.1% of the management personnel can be considered competent in terms of knowledge, skill and ability in carrying out occupational safety and health regulation within their respective organization. While, 96.9% of the respondents that participated in the survey can be considered not competent. The authors hope the result of this survey could assist the relevant authorities in formulating a better policy and strategy for implementing occupational safety and health in SMEs involved in chemical industry sub-sectors.

Keywords: Occupational Safety and Health; industry; SMEs; Chemical

Introduction

The regulation on public safety can be traced back to the era of King Hammurabi in Babylon since 2500 BC. The infamous Hammurabi Code inscribed on stone dictates that any person who is guilty of causing the death of a person would be punishable by death (Bahari 2006). After more than four millenniums, the safety regulation had evolved with most changes occurred after the industrial revolution (Hassan 2003; Bahari 2006). In our modern world, industrial safety aspect is no longer regarded as trivial and any accident is no longer being accepted merely as fate. More positive efforts are being taken by all the stakeholders to improve the level of occupational safety and health. The two main objectives of this study are: first, identify level of conformance to OSHA (1994); and second, investigate the reasons of their nonconformity among SMEs in chemical industry sub-sectors in Malaysia. Past studies conducted by researchers such as Onn (1999), Basri (2000), Man (2000), Ng & Selva (2003), and Piah (2005) reported that SMEs workplaces are prone to accidents and illness.

In Malaysia, the regulation on occupational safety is embedded into two acts, Factory and Machinery Act (FMA, 1967) and Occupational Safety and Health Act (OSHA, 1994) that were enforced by Department of Occupational Safety and Health (DOSH). Within large companies, the evolution towards improvement of Occupational Safety and Health (OSH) practices was apparent with many of them voluntarily implement various types of occupational safety and health management system (Bahari et al. 2008). In many past researches carried out in Europe, the level of
occupational safety within multinationals and large companies were high but in SMEs premises they are below the minimum standards (Jeynes 1999).

SMEs are very concerned because the newly introduced legislations are putting pressure on them as employers to be more responsible for elements outside their control (Budworth 2000). In many SMEs, the employees have no union and more likely to be involved in more hazardous industrial sectors or those that rely on face-to-face contact with customers (Walters & James 1998). SMEs are usually involved in industries that are not technologically adaptable or those which are not flexible in their work organization (European Foundation 1997; Clifton 1998).

**Methods**

The important elements studied in this research are the SMEs conformity, top management’s perceptions and competencies with respect to characteristics found in FMA (1967) and OSHA (1994) regulations in Malaysia.

The survey methodology was employed to determine three main dimensions (i.e. level of conformity, perception and competencies) of SMEs in chemical industry sub-sectors. These three dimensions are very important in this research, therefore various reliability and validity tests were conducted on the survey questionnaire. The survey questionnaire was used to collect data on SMEs conformity or non-conformity and state of readiness in chemical industry sub-sectors in implementing FMA (1967) and OSHA (1994).

The survey questionnaire was validated by 20 health and safety executives or managers working in SMEs. The questionnaire has a high reliability and validity value because more than 80% of the respondents agreed that the questions are suitable to measure SMEs conformity, top management’s perception and competency with respect to FMA (1967) and OSHA (1994).

Reliability is the extent to which a score from a selection of measures that is stable and free from error. One way to determine the reliability of a test is to look at the consistency in which a respondent responds to items measuring a similar dimension. The extent to which same items are answered in similar ways is referred to as internal consistency and measures items stability. In general, longer tests may provide results with higher internal consistency, i.e. the agreement among the responses to the various test items (Herman 2003; Chua 2008).

Cronbach’s alpha can be used to determine the research instrument’s internal reliability (Herman 2003; Chua 2008; Sekaran 2006). According to Pallant (2001), Cronbach’s alpha is the most commonly reported measure of internal reliability and the median internal reliability coefficient of 0.7 found in the research literature is acceptable. The result of the pilot survey shows the value for Cronbach’s alpha is 0.945, which can be concluded that survey instrument has a high reliability.

Data gathering takes about 3 months beginning in November 2009 until January 2010. The survey was carried out in SMEs located in Klang Valley, Johor, Kedah, Kelantan, Penang and Sabah involved in chemical industry sub-sectors. In Malaysia, there are 1047 SMEs involved in chemical industry sub-sectors. According to Roscoe (1975), sample sizes larger than 30 and less than 500 are appropriate for most research. In total 41 survey questionnaires were completed and returned. The data obtained was analyzed using Statistical Package for Social Science (SPSS) for Windows Version 16 and followed the guidelines provided by Pallant (2001).
Descriptive statistical method was used to calculate the data as well as to report the results such as percentage, mean and standard deviation. Inferential method (Spearman correlation coefficient and t-test) are based on the examples described by Herman (2004) and Chua (2008).

Results and Discussion

There are 12 items in the research instrument that measures conformity of the responding company towards OSH regulation. As such the total maximum score would be 60. To determine the level of conformity, the score is translated into the mean range. A mean score $\geq 4.0$ shows the respondent’s company is considered to conform to the OSH regulation. A mean score of 3.0 to 3.9 would put the respondent’s company to be in the intermediate level of conformity which reflects that the respondent is not conforming to the OSH regulation and but steps are taken towards conformity. Only respondents companies with score $\leq 2.9$ are regarded as not conform to OSH regulation. The results of the conformity level are shown in Table 1.

<table>
<thead>
<tr>
<th>Sub-sector</th>
<th>Not Conform</th>
<th>Intermediate</th>
<th>Conform</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical industry</td>
<td>36.5%</td>
<td>56.2%</td>
<td>7.3%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Among the total 41 respondents SMEs from the chemical industry sub-sectors, only three companies had actually conformed to OSH regulation. For chemical industry sub-sector, majority of the respondents (56.2%) were within the intermediate level while (36.5%) had not conformed.

In general, the result shown in Table 1 indicates that a large majority of SMEs factories within the chemical industry sub-sectors had not conforms to OSH regulation. A study by Jeynes (2002) in Europe also found low compliance of small industries towards OSH regulations. Similarly, in this survey it was found that about 80% of the respondents had admitted not complying with OSH regulation or having little knowledge of OSH management systems and only reacted to the problem as it arise.

3.1 Competency among Top Management

In order to carry out the analysis for Competency among the Top Management, the score is transformed into the mean range. By achieving a mean score of 4.0 or more, the top management of the company is considered to be sufficiently competent for implementing the OSH regulation in their respective companies. A mean score of less than 2.9 indicates the top management is not competent to implement the OSH regulation within their companies. A mean score of 3.0 to 3.9 indicates the top management is not yet competent and they need some effort to reach the required competency level. The competency levels of the respondents are summarized in Table 2.

<table>
<thead>
<tr>
<th>Sub-sector</th>
<th>Not Competent</th>
<th>Intermediate</th>
<th>Competent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical industry</td>
<td>4.88%</td>
<td>87.80</td>
<td>7.32%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>
Referring to Table 2, only 7.32% of respondents can be considered to be competent in terms of having appropriate knowledge, skill and ability in carrying out OSH regulation within their respective organizations. The remaining respondents can be considered not competent, with majority in the intermediate level (87.80%). Only 4.88% of respondents fall into the bottom category where they have no ability, skill or knowledge to implement OSH regulation at the workplace.

3.2 Reasons for Non-Conformity

The respondents were asked the reasons why their companies were unable to conform to the OSH regulation. All the respondents answered this question and none had offered an alternative reason than those offered in the survey questionnaire. Only, 10% of the respondents believed that they are conforming and majority (90%) of them admitted that they are not conforming to the OSH regulation. The reasons ranking and percentage of nonconforming to OSH regulation are shown in Table 3.

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Reason</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No knowledge</td>
<td>34.9</td>
</tr>
<tr>
<td>2</td>
<td>Difficult and Expensive</td>
<td>27.9</td>
</tr>
<tr>
<td>3</td>
<td>Low Risk</td>
<td>23.3</td>
</tr>
<tr>
<td>4</td>
<td>Not aware</td>
<td>7.0</td>
</tr>
<tr>
<td>5</td>
<td>Following Others</td>
<td>2.3</td>
</tr>
<tr>
<td>6</td>
<td>No Advantage</td>
<td>2.3</td>
</tr>
<tr>
<td>7</td>
<td>No description</td>
<td>2.3</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>100.0</td>
</tr>
</tbody>
</table>

From seven reasons offered, the respondents can only choose five of them. The top three reasons selected by the respondents are: the lack of staff with knowledge on how to implement and comply with OSH regulation (34.9%); followed by a negative perception that it is difficult and expensive to comply with the regulation (27.9%); and the respondents believe that they are working in low risk work environment (23.3%). These two reasons are similar to the findings of a previous study done in Europe when the European Union (EU) directives were first implemented.

As regards to the lack of knowledge, the European Commission had acknowledged the problem and specifically state that guidance aimed at small firms should be made “helpful and effective in implementation of legal provisions” (EC 1999). The regulation and ways to implement them also should be clear and any publication of a range of tools should be aimed at the man in the street (UNICE 2182/26).

The financial constraint issue is also a barrier that had been found to exist in SMEs in Europe. There is a perception that it will cost money to comply with all relevant health and safety laws, and in some situations this may be the case (Wright 1998; Vassie & Cox 1998). Ultimately the burden of compliance falls disproportionately on the smallest firms. In this study, cost is not the primary concern of research respondents; however it is an important issue when putting necessary measures into place. Jeyney (2000) believe that particular evaluation on the type of help (i.e. level of expertise needed and the required financial outlay) should be carried out first.
Conclusion

Within its due limitations, the study was able to provide answer to all the objectives. The survey result indicates; the overall level of conformity is still low among respondents that participated in the survey of SMEs in the chemical industry sub-sectors. There is a positive perception of OSH regulation among top managers of the responding SMEs. Unfortunately, the positive perception was not translated into a better conformity towards the OSH regulation. The survey result revealed that there is a strong relationship between the competency of top managers and conformity towards OSH regulation in SMEs. However, an overwhelming majority of the top managers in the SMEs surveyed were not competent to implement OSH requirement within their organization. The two main barriers indicated by the respondents are due to lack of staff with the required know-how and financial resources to implement OSH regulation. The survey indicates that majority of the SMEs either did not have any OSH management systems or only has very little OSH expertise. On overall, the survey had indicated that there is still much need to be done in promoting more SMEs to conform to OSH regulation in their workplace. To achieve this, the Malaysian government through its agencies such as DOSH, NIOSH and National Council for Occupational Safety and Health are urged to intensify their efforts in promoting OSH awareness by visiting their premises, conducting seminars, workshops, road-shows, and publishing articles in the local mass media.

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Modelling and Optimization Approach of Quantitative Environmental Ergonomics in Malaysian Automotive Industry

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Abstract

Environmental factors such as temperature, lighting and noise have very significant impact to workers’ health, safety, comfort, performance and productivity. In an ergonomically design industrial work environment, these factors need to be control at their optimum levels. The main objective of this study is to find the effect of temperature, illuminance and sound pressure level on workers’ productivity in automotive industry. To perform this study a workstation in an automotive component manufacturing was selected as the location of the study. Results of data analysis showed there were relationships between temperature, illuminance and noise on workers’ productivity. Later, the authors’ developed multiple linear equation models to represent the relationships between temperature, illuminance and noise on the workers’ productivity. These multiple linear equation models could be used to predict the production rate for the workstation by referring to the value of temperature, illuminance and noise level.

Keywords: temperature; illuminance; noise; productivity

Introduction

In industry, the productivity could be increased in a variety of ways. A comfortable employee can produce more than a counterpart who is working in an uncomfortable work environment throughout the day. A comfortable working environment can do more than making workers happy because it can also improve their productivity. For example, raising workplace temperature can have a drastic effect on office productivity. Lee and Brand (2005) found in their study that environmental factors in physical office environment such as: noise, lighting, temperature, existence of windows could influence employee attitudes, behaviours, satisfaction and performance.

There is a continuous and dynamic interaction between people and their surroundings that produces physiological and psychological strain on the person. This can lead to discomfort, annoyance, faint and directly affects their performance and productivity, health and safety, and can also cause death. For instance, performance can be dramatically affected by loss of manual dexterity in the cold, noise interfering with speech communication or work time lost because the environment is unacceptable or distracting. Apart from that, accidents can also occur due to glare on displays, missed signals in a warm environment or disorientation due to exposure to extreme environments (Parson, 2000).

Workplace conditions such as extreme heat or cold, noise and poor lighting have direct or indirect effects on employees’ job performance. These extreme conditions may reduce employees’
concentration towards their tasks which can lead to lower employees’ performance in performing their task and result in low productivity, poor quality, physical and emotional stress and higher production cost (Kahya, 2007). The feelings of eye fatigue, distraction, difficulty of seeing letters, and annoyance are significantly influenced by fluctuating light levels (Kim and Kim, 2006). Relative humidity could influence an employee’s perception of comfort during his/her working hours (Attwood et al., 2004). Zaheeruddin and Garima (2006) noted that work efficiency for the same exposure time would decrease by raising the noise level.

Effective applications of ergonomics principles in work environment may enhance employee job performance by providing safety, physical well-being and also contribute to job satisfaction (Kahya 2007). It can be concluded that awareness and understanding on the effect of environmental factors is important to improve workers’ performance and to prevent a workplace accident.

Methods

2.1 Selection of Study Location
A workstation, which is currently facing problems that relate to environmental factors such as: temperature, lighting and noise was chosen in this study. A workstation which produced an amount of products in a range of time and under the effects of temperature, illuminance and noise was chosen. This criterion is essential to see the effect of the temperature, illuminance, and noise on the worker’s productivity.

2.2 Information Gathering and Data Collection
Information on anthropometric data and measurement of environmental data are important in this study. The information about workers’ anthropometric data and measured data of Wet Globe Bulb Temperature (WBGT), illuminance, relative humidity, noise level and amount of products produced were gathered. WBGT and humidity were measured by using QuestTempº 36 equipment, illuminance was measured by using Photometer equipment and noise was measured using Sound Level Meter equipment. The production rate represents the workers’ productivity. Amount of products taken at every 30 minutes interval were compared with the value of temperature, illuminance, sound pressure level and humidity measured. Figure 1 shows a flow diagram for the study methodology carried out.

2.3 Case Study
A case study was done to examine the effect of temperature, illuminance and noise level on the workers’ productivity. A workstation in an automotive component manufacturing industry was chosen as the location for the study. The workstation function as an assembly workstation for car door frame, it has 5 male operators. Figure 2 shows the selected workstation area, Figure 3 shows a layout of the workstation and Figure 4 shows a process flow for the workstation in this study. This workstation is targeted to produce 30 units of product in every of 30 minutes interval.
Results and Discussion

3.1 Multiple Linear Regression Analysis
Multiple linear regression analysis was conducted to show a relationship between dependent variable (i.e. production rate) with all independent variables as temperature, illuminance and sound pressure level. Table 1 shows data of the production rate, illuminance, noise level and the time duration for every 30 minutes.

Figure 1: Flow diagram for the methods of the study

Figure 2: Workstation Area
In a multiple linear regression model, it is customary to refer to $R^2$ as the coefficient of the multiple determinations. For the productivity regression model, $R^2 = 0.891$ and the output reports $R^2 \times 100\% = 89.1\%$. This can be interpreted as indicating that the model is containing noise, WBGT and illuminance for approximately 89.1% of the observed variability in productivity. It is reasonable to conclude that $x_j$ is significantly related to independent variables related to production rate in the regression model under consideration, if $H_0$ can be rejected in favour of $H_a$ at a small level of significance. The t-value for WBGT $t_1 = -2.905$ has a p-value of 0.034, which indicates that the regressor WBGT contributes significantly to the model. But the t-value for illuminance $t_2 = -1.158$ has a p-value of 0.083 and noise $t_3 = -0.549$ has a p-value of 0.607 contributes insignificantly to the model. It shows that only WBGT is significant for the equation model.

Results from Kahya (2007) study showed that there is a relationship between workers' performance and workplace environment. Poor workplace conditions (physical efforts, environmental conditions and hazards) may result in lower employees’ performance.

### Table 1: Data Collected for WBGT, Illuminance and Noise Level with Production Rate

<table>
<thead>
<tr>
<th>Time (Hrs)</th>
<th>Production Rate (Units)</th>
<th>WBGT (°C)</th>
<th>Illuminance (lux)</th>
<th>Noise Level (dBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.30-10.00</td>
<td>36</td>
<td>26.2</td>
<td>367</td>
<td>85.5</td>
</tr>
<tr>
<td>10.30-11.00</td>
<td>31</td>
<td>26.8</td>
<td>412</td>
<td>87.1</td>
</tr>
<tr>
<td>11.00</td>
<td>32</td>
<td>27.1</td>
<td>382</td>
<td>87.6</td>
</tr>
<tr>
<td>11.00</td>
<td>30</td>
<td>27.4</td>
<td>373</td>
<td>87.2</td>
</tr>
<tr>
<td>11.30-12.00</td>
<td>32</td>
<td>27.6</td>
<td>359</td>
<td>84.6</td>
</tr>
<tr>
<td>12.00-12.30</td>
<td>33</td>
<td>26.6</td>
<td>289</td>
<td>83.2</td>
</tr>
<tr>
<td>2.30-3.00</td>
<td>37</td>
<td>26.4</td>
<td>322</td>
<td>84.0</td>
</tr>
<tr>
<td>3.30-4.00</td>
<td>34</td>
<td>26.4</td>
<td>315</td>
<td>84.1</td>
</tr>
<tr>
<td>4.00-4.30</td>
<td>36</td>
<td>26.2</td>
<td>283</td>
<td>83.6</td>
</tr>
<tr>
<td>4.30-5.00</td>
<td>38</td>
<td>26.2</td>
<td>283</td>
<td>83.6</td>
</tr>
</tbody>
</table>

### Table 2: Multi-linear Regression Analysis for the WBGT, Illuminance and Sound Pressure Level With Production Rate

<table>
<thead>
<tr>
<th>Model Summary</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple R</td>
<td>0.944</td>
</tr>
<tr>
<td>R Square</td>
<td>0.891</td>
</tr>
<tr>
<td>Adjusted R Square</td>
<td>0.825</td>
</tr>
<tr>
<td>Standard Error</td>
<td>1.200</td>
</tr>
</tbody>
</table>
### ANOVA

<table>
<thead>
<tr>
<th></th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>3</td>
<td>58.794</td>
<td>19.598</td>
<td>13.599</td>
<td>0.008</td>
</tr>
<tr>
<td>Residual</td>
<td>5</td>
<td>7.206</td>
<td>1.441</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>66.000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Coefficients

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
<th>95% Confidence Interval for B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>144.945</td>
<td>46.660</td>
<td>3.106</td>
<td>0.027</td>
<td>25.002 - 264.888</td>
</tr>
<tr>
<td>WBGT</td>
<td>-2.802</td>
<td>0.965</td>
<td>-0.505</td>
<td>-2.905</td>
<td>0.034 -5.282 -0.323</td>
</tr>
<tr>
<td>Illuminance</td>
<td>-0.026</td>
<td>0.022</td>
<td>-0.400</td>
<td>-1.158</td>
<td>0.299 -0.083 0.032</td>
</tr>
<tr>
<td>Noise</td>
<td>-0.318</td>
<td>0.579</td>
<td>-0.188</td>
<td>-0.549</td>
<td>0.607 -1.806 1.170</td>
</tr>
</tbody>
</table>

**3.2 Determination an Optimum Value for Each Environmental Factor**

To determine an optimum value for WBGT, illuminance and sound pressure level, the comparison between the calculated values and permissible standard values were made. To obtain the WBGT value, the standard value is based on the value which was issued by ISO 7243:1982 according to the worker’s metabolic rate. The standard value for the illuminance and sound pressure level were referred to the value proposed by IFC Environmental Guidelines for Occupational Health and Safety.

From the regression linear model, an optimum WBGT value to produce a total 30 units of product in 30 minutes was predicted. From the calculation, an optimum value for WBGT is 27.6 °C. Based on the ISO 7243 WBGT standard, the calculated WBGT value is lower than the maximum standard value at 30 °C, the workers have metabolic rate between 117 Wm² to 234 Wm². Therefore, this value is suitable to determine the total 30 units production rate for the studied workstation.
From the calculation, an optimum illuminance value obtained was 417.75 Lux. Based on the illuminance standard by IFC Environmental Guidelines for Occupational Health and Safety, the calculated value is lower than maximum standard value (i.e. 500 lux), which is required for the tasks that need high precision (i.e. welding, inspection and finishing). Therefore, this value is suitable to determine the total 30 units production rate for the studied workstation.

For sound pressure level, calculation from the model equation gave an optimum value of 88.16 dBA to produce the total 30 units of product in 30 minutes. According to the standard sound pressure level value by IFC Environmental Guidelines for Occupational Health and Safety, the calculated value is higher than the standard value of 85 dBA permissible for heavy industry. Therefore, the calculated value is not suitable to determine the total 30 units of production rate and to provide the safety workplace for the studied workstation. By using the multilinear regression:

\[
\text{Production rate} = 144.945 - 2.802 \times [\text{WBGT}] - 0.026 \times [\text{Illuminance}] - 0.318 \times [\text{Sound pressure level}]
\]

To achieve the total 30 units of production rate and get an optimum value for each factor without exceeding the permissible standard limits, the calculated values were found by using linear regression model linear need to be changed to provide safety workstation. Table 3 is showed new optimum values for each factor that calculated through multi linear regression.

<table>
<thead>
<tr>
<th>Environment Factor</th>
<th>Standard Value</th>
<th>Calculated Value</th>
<th>New Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBGT</td>
<td>30 °C</td>
<td>27.6 °C</td>
<td>28 °C</td>
</tr>
<tr>
<td>Illuminance</td>
<td>500 lux</td>
<td>417.75 lux</td>
<td>424 lux</td>
</tr>
<tr>
<td>Sound Pressure Level</td>
<td>85 dBA</td>
<td>88.16 dBA</td>
<td>80 dBA</td>
</tr>
</tbody>
</table>

**Conclusion**

The objectives of the study are to obtain the environmental parameters such as: temperature, illuminance and sound pressure level on the workers productivity at selected workstation in automotive industry were achieved successfully. Later relates them with mathematical model equations to indicate the relationship between environmental parameters and employee productivity. Apart from that, based on the amount of product that produce in a time period; the correlation and regression analysis represents the relationship between temperatures, illuminance and sound pressure level on workers’ productivity. Multi regression analysis indicates there is a relationship between all parameters and workers productivity. However, only Wet Bulb Globe Temperature (WBGT) has a strong effect to employees’ productivity in this studied workstation.

Result of the study shows the optimum values for: temperature is 28°C; illuminance is 424 lux and sound pressure level is 80 dBA respectively for the workstation. Obtainable value is limited only to a workstation that performs assembly and installation of car door frame. This is because workstation for each type of industrial sector has different environment and also other factors that need to be considered to acquire higher productivity.

**References**


A Survey on Work-related Musculoskeletal Disorders (WMSDs) among Construction Workers

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3Sports and Human Group (SHEG), Faculty of Mechanical Engineering, Universiti Malaysia Pahang, 26600 Pekan, Pahang.

Abstract
Work-related Musculoskeletal Disorders (WMSDs) are common occupational injuries among workers in the construction industry. Epidemiological studies indicated that WMSDs include neck pain, lower back pain, knee pain, leg fatigue as well as ankle and feet discomfort. The objectives of this study are to identify the WMSDs experienced by the workers during construction works and discuss the causes of those WMSDs. Subjective approach associated with modified Nordic Musculoskeletal Questionnaire (NMQ) was applied to identify the symptoms of WMSDs. A case study was conducted in several construction sites situated at the southern region of Peninsular Malaysia. During the study, 37 construction workers with different age and scope of works were interviewed to determine the WMSDs that they have experienced. Based on distributed questionnaire, almost all workers experienced pain in the region of lower back, upper back and biceps. These pains were contributed by manipulation of heavy load and high force exertion. Based on discussed causations, control measures via engineering controls method and administrative controls method were proposed to alleviate the risk of WMSDs among construction workers.

Key words: Work-related Musculoskeletal Disorders (WMSDs), construction industry, occupational risk factors, subjective approach.

Introduction
It is well known that the construction field is unique among other industries as the workers in this area are exposed to indoor and outdoor conditions. Construction industry is important to people because it is capable to provide large opportunity of employment to both skilled and unskilled workers1) either locally or from other countries. In Malaysia, construction industry offers job opportunities to 791900 workforces in 2003 and rose to 798200 in 20042). Instead of providing good job opportunities, the huge numbers of workers are susceptible to occupational injuries associated with work-related musculoskeletal disorders (WMSDs) if effective measures are not given priority. In global scenario, construction industry reports the highest industrial accident rate in the world of work. Construction workers are also those who are perceived to be lacking of job safety. A study has shown workers in the construction sites have to face constant change in the nature of work, the location of work and the mix of workers. Besides, the workers in this industry frequently work with heavy materials and machineries and are exposed to hazardous environmental risk factors such as noise, dusts as well as heat stress. Working in very hot weather has physiological and psychological effects on workers; it reduces their productivity, increases their irritability and loss of their enthusiasm for their work3, 4).

Most of the people tend to relate construction industry with dangerous working environment and high risk as compared to others5). International Labor Organization (ILO) reported that there were two million workers died every year because of occupational injuries and accidents6). According to United States Public Health Service, construction industry was identified as one of significant contributors to highest rate of WMSDs associated with Cumulative Trauma Disorders (CTD) and lower back pain7). In Malaysia, Social Security Organization (SOCSO) reported cases involving construction industry were 4873, in which 642 cases were of permanent disability and 159 cases were of fatality for the year 20008).

In recognition to the numbers of occupational risks contributed by construction industry, this study initiated a preliminary investigation with the following objectives:
1. to investigate WMSDs experienced by the workers during construction works.
2. to discuss the causes of major pain or discomfort associated with construction works.
A Survey on Work-related Musculoskeletal Disorders (WMSDs) among Construction Workers

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In recognition to the numbers of occupational risks contributed by construction industry, this study initiated a preliminary investigation with the following objectives:
1. to investigate WMSDs experienced by the workers during construction works.
2. to discuss the causes of major pain or discomfort associated with construction works.

Method

Basically, this study is based on qualitative study that requires researchers obtain the information directly from the construction sites. As a starting point, the researcher conducted a walkthrough observation at the construction site in order to obtain the types of risk factors and potential WMSDs imminent to the workers due to those risk factors. Based on the walkthrough observation, the researcher found that subjective approach associated with musculoskeletal questionnaire would be an appropriate method to perform a preliminary investigation. A questionnaire
which is designed based on Nordic Musculoskeletal Questionnaire was used as a tool to investigate the WMSDs experienced by the construction workers. The researcher brought the questionnaire to the construction site and workers were directly interviewed to acquire their response. The questionnaire consists of a series of questions with multiple-choice responses. The questions were grouped into sections dealing with general information of the workers, areas of pain or discomfort after doing the works, major pain or discomfort during the works, the cause(s) of the pain or discomfort and types of treatment(s) for the pain or discomfort. The detail of the questions as follow:

(i) Using the diagram below (Fig. 1), please circle any areas of pain or discomfort that you feel after doing the works.

(ii) Specify the major pain or discomfort occur during doing the works.
- chest
- abdominals
- upper back
- lower back
- biceps
- quadriceps
- triceps
- hamstrings
- gluteals

(iii) What is the cause(s) of the pain or discomfort?
- manipulation of heavy load
- high force exertion
- awkward working posture
- static loading
- repetitive works

(iv) What types of treatment(s) for the pain or discomfort?
- medicine
- injection
- surgery
- hot bath
- X – ray
- massage
- Paraffin
- other

Field Study
A field study was conducted to several construction sites situated at southern region of Peninsular Malaysia. During the study, total of 37 construction workers were selected and interviewed to acquire their response regarding to WMSDs that they have experienced. The workers were selected from different nationality, race, age, physical size and scope of works. The workers were observed to work very intensively, long duration of work hours and perform the jobs in hot weather condition.

In a construction site, there are many types of activities ranging from simple job such as housekeeping until high risk job such as assembling the roofs on the top of building.

Results
This section presents the reports of workers regarding to the area of pain or discomfort experienced by them, the type of major pain or discomfort which occur while performing the work, the causes of major pain or discomfort and the type of treatment for the pain or discomfort. Each complaint is described in the following sections.

Areas of pain or discomfort experienced by the workers
Results for the question (i) indicate that almost all workers experience pain or discomfort on the area no. 2 (lower back), no. 6 (shoulder) and no. 16 (leg). For the area no. 9 (upper arm), no. 10 (elbow) and no. 11 (elbow), rare cases of pain or discomfort are reported. Out of 37 interviewed workers, there is only one worker reported pain in the area no. 8 (buttock).

Major pain or discomfort while performing the work
Referring to Table 1, major pain or discomfort on the upper back, lower back and biceps were found to be among the critical cases as majority of workers reported pain on these areas. Meanwhile, triceps and hamstrings were the next reported area of pain and discomfort. However, little or no report for the pain on chest, abdominals, quadriceps and gluteals.

Table 1. Major pain or discomfort while performing the work

<table>
<thead>
<tr>
<th>Area</th>
<th>No. of worker</th>
</tr>
</thead>
<tbody>
<tr>
<td>chest</td>
<td>4</td>
</tr>
<tr>
<td>abdominals</td>
<td>1</td>
</tr>
<tr>
<td>upper back</td>
<td>25</td>
</tr>
<tr>
<td>lower back</td>
<td>22</td>
</tr>
<tr>
<td>biceps</td>
<td>26</td>
</tr>
<tr>
<td>quadriceps</td>
<td>2</td>
</tr>
<tr>
<td>triceps</td>
<td>16</td>
</tr>
<tr>
<td>hamstrings</td>
<td>13</td>
</tr>
<tr>
<td>gluteals</td>
<td>0</td>
</tr>
</tbody>
</table>

Causes of major pain or discomfort occur during doing the works
Table 2 presents the causes of major pain experienced by the workers due to construction works. Manipulation of heavy load, awkward working posture and high force exertion were reported as main contributors to major pain, while the
causes related to static loading and repetitive work are rarely complained.

**Table 2. Causes of major pain or discomfort occur during doing the works**

<table>
<thead>
<tr>
<th>Causes of pain</th>
<th>No. of complaint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manipulation of heavy load</td>
<td>15</td>
</tr>
<tr>
<td>High force exertion</td>
<td>7</td>
</tr>
<tr>
<td>Awkward working posture</td>
<td>9</td>
</tr>
<tr>
<td>Static loading</td>
<td>4</td>
</tr>
<tr>
<td>Repetitive work</td>
<td>1</td>
</tr>
</tbody>
</table>

**Table 3. Type of treatment for the pain**

<table>
<thead>
<tr>
<th>Type of treatment</th>
<th>No. of report</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medicine</td>
<td>11</td>
</tr>
<tr>
<td>Injection</td>
<td>1</td>
</tr>
<tr>
<td>Surgery</td>
<td>0</td>
</tr>
<tr>
<td>Hot bath</td>
<td>0</td>
</tr>
<tr>
<td>X - ray</td>
<td>0</td>
</tr>
<tr>
<td>Massage</td>
<td>10</td>
</tr>
<tr>
<td>Paraffin</td>
<td>4</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
</tr>
<tr>
<td>No action</td>
<td>10</td>
</tr>
</tbody>
</table>

**Discussion**

This section discusses the causes of major pain or discomfort occurred during workers performing their jobs. Based on the conducted survey, they are several causes identified i.e. manipulation of heavy load, high force exertion, awkward working posture, static loading and repetitive works. Each cause is discussed in the following sections.

**Manipulation of heavy load**

Manipulation of heavy load occurred when the workers carry long steel pipe and concrete cements (Fig. 2). While performing those jobs, a worker is required to hold and move the load with high muscular force. These jobs may lead to acute overload or fatigue of muscles especially in the area of lower back and shoulders. Repeated manipulation of heavy long steel pipe at the construction site and lifting cement bags or other equipment onto the lorry will affect the upper body muscles. On top of that, the jobs also exert high forces on the musculoskeletal system can contribute to the risk of acute overloading and tissue damage. If the loading occur over a long period of time, they may cause or promote degenerative disorders especially in the lower back area.

The most important factors concerning the risk associated with heavy load manipulation are the weight of the object to be manipulated, the horizontal distance between the load and the body and the duration and repetition frequency of task execution. Consequently, these factors lead to some important measures for handling objects.

**Fig. 2. Manipulation of heavy load**

**High force exertion**

High force exertion is a risk factor obtained when the worker lifts heavy objects such as sacks of cement and bricks from one location another. This is clearly shown in Fig. 3 whereby a worker transfers sacks of cement from a container into a wheelbarrow without using any tool to assist the job. He was using his back and shoulder strength to perform the job. High amount of forces were exerted uniformly on his trunk, and in case he lifted the objects by using his back strength and allowed forces to concentrate on the his L5/S1, it will potentially contributes to damage of his lumbar spine tissues.

**Fig. 3. Worker transferring sacks of cement from a container into a wheelbarrow**

**Fig. 3. Worker transferring sacks of cement from a container into a wheelbarrow**
Awkward working posture

Awkward working posture always occurs when the construction workers perform the job with their body parts deviating significantly from the natural posture. This can be obtained from the routine jobs such as flattening the land using a hoe and digging the land to form drainage line. When performing job in awkward working posture, high force was applied in the skeletal system and may lead to acute overloading and damage of skeletal structures. Prolonged jobs with inclined trunk will create WMSDs associated with lower back pain especially in the lumbar region.

Static loading

Risk factor associated with static loading was observed while the workers performing painting of the building wall. During the painting process, the worker has to perform the job continuously in standing posture. Prolonged standing can lead to muscle fatigue and irreversible changes in the muscular structure if the worker is not given sufficient recovery time. Conversely, the risk of the muscle fatigue also may contribute to injuries to the worker. For example, when the worker performs overhead painting work, he will tend to have major problem on the neck and shoulder.

Repetitive works

Risk factor associated with repetition is identified while the workers perform bricklaying process. Bricklaying is part of construction work that are mostly carried out conventionally. The researcher found that the ways of bricklaying process, materials, equipment and working environment are hazardous and need immediate improvement actions to minimize the occupational injuries. During the bricklaying process, workers handled the brick with average weight of 1 to 5 kg using one side of their hand repetitively. Normally, bricklaying process is performed by a group which consists of bricklayer and assistant. The bricklayer will be lifting and applying mortar or stone (1 to 5 kg), while the assistant will be lifting and carrying the material with average load of 25 kg for more than 4 hours a day.

Suggestions for Improvement

Based on the discussed causes of major pain or discomfort, control measures to alleviate the risk of WMSDs among construction workers should be developed. Among them are engineering controls method and administrative controls method.

Engineering controls method

Engineering controls refer to the use of engineering techniques such as implementation of proper materials handling devices so that the risks associated with manipulation of heavy objects and high force exertion could be minimized. For example, the use of machined crane can help the workers to manipulate the transfer of the long steel pipe thus reducing the usage of human efforts. In case the use of machined crane is impossible to be implemented due to limited space or finance constraint, manual portable crane can be proposed to diminish the muscle fatigue associated with high force exertion.

Administrative controls method

Besides, administrative controls also can be applied. Administrative controls refer to the management of exposure time for construction jobs. Through this method, optimum working time and rest time can be proposed. A previous proposed that for moderate category of workload with 30.6 °C to 32.3 °C, the recommended Wet Bulb Globe Temperature (WBGT) index for work-rest schedule should be 50% working time and 50% rest time. Working with WBGT more than 38 °C should not be practiced to avoid the risk of heat strain. Other than that, workers’ welfare should be considered to improve occupational health in the construction industry. A comprehensive training on construction works should be conducted among the workers so that they will be more knowledgeable and concern about their health. Previous study addressed the following recommendations to improve the work condition:

a) provides clean and safe drinking water to the workers.
b) redesign work tools based on workers’ anthropometry.
c) reorganized materials for easy reach of workers.
d) provides adequate and appropriate personal protective equipment (PPE).

Conclusion

The researchers have conducted a survey and identified that lower back pain, upper back pain and biceps pain are the most common WMSDs in construction industry. From the study also, the researchers found that the major causes of the mentioned WMSDs are contributed by poor working conditions such as manual manipulation of heavy load and high force exertion. These causes were discussed and suitable solutions were proposed to improve the occupational health of worker in the construction industry so that they will be more productive and competitive in their works.

Acknowledgement

The researchers would like to acknowledge the Faculty of Manufacturing Engineering (FKP) of UTeM for providing the facilities in carrying out this manuscript. Finally, the authors would like to thank all the people who had participated in this study.
References


A Survey on Work-related Musculoskeletal Disorders (WMSDs) among Construction Workers
Workplace injuries in Malaysian Manufacturing Industries

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ABSTRACT
This study analyzes the determinants of workplace injuries across 44 four-digit manufacturing industries in Malaysia from 1993 to 2008 through the business cycle and structural approaches. The results of fixed-effects estimations revealed that workplace injuries in Malaysian manufacturing sector were negatively influenced by firm size and positively influenced by business cycle. Consistent with the findings of previous studies in other countries, the empirical evidence of this study supports the pro-cyclical behavior of injury rates in manufacturing industries towards business cycle. The analysis demonstrates that both structural and cyclical variation effects are important determinants of workplace injuries in Malaysia.

Keywords: workplace injuries, cyclical variation, structural characteristics, Occupational Safety and Health Act.

INTRODUCTION
Studies on the incidence of industrial accidents or workplace injuries can be grouped into three approaches, viz. business cycle, labor market and structural approaches. The business cycle approach to workplace injuries provides explanations as to how injury rates may be expected to vary over the course of the economic cycle (Kossoris, 1938; Leigh 1985; Robinson and Shor, 1989). These studies support pro-cyclical relation, showing that the number of injuries tend to increase during economic upswings and vice versa. Nevertheless, this approach does not explicitly consider the interaction of choices made by employers between safety and profits and the choices of employees between safety and wages in determining the risk of injuries. This give rise to the second approach, the market oriented approach to workplace injuries as proposed by Chelius (1974), Oi (1974), and Sider (1985). Their studies relate the injury rates to the market factors, such as wage and government control. In general, their analysis shows that, under firm’s optimization, occupational injury is determined by wage level and employers incentives in accident prevention. However, the impact of government intervention through tax and compensation benefit is inconclusive.

The third approach focused on structural effect of the industry such as workers characteristics, firm size, and mechanization or capital intensity in the production process (Oi, 1974; Cooke and Gautschi, 1981; Viscusi, 1986; Currington, 1986). Demographic differentials in work injury rates could have been generated by several structural forces. If other things being equal, (such as type of industry, occupation, firm size and safety of the work site), certain workers are innately more liable to be involved in workplace injuries (Oi, 1974).

Despite the three approaches, it is often assumed that the causes of accidents vary across sectors (Coleman, 1981). A survey report by Centers for Disease Control and Prevention (1993) on fatal injuries in the United States (U.S.) during 1980-1989 shows that the largest number of fatalities occurred in the construction sector, followed by transportation, manufacturing, and primary economic sectors. A large body of existing empirical analysis on workplace injuries focused on manufacturing and construction sectors. This is due to their natural hazard and both sectors are found to be highly responsive to the business cycle, particularly in mature capitalist economies as well as those in transition towards industrialized economies (Robinson and Shor, 1989; Davies et al., 2009).

With the vision of becoming an industrialized economy by the year 2020, Malaysia has started its industrialization effort since 1960s. Industrialization has been an integral part in the Malaysian development strategies and manufacturing sector has shown to be one of the important backbones and a major contributor to the Malaysian economy. The share of manufacturing sector to Gross Domestic Product (GDP) increased significantly from only 12.2 percent in 1970 to 30.1 percent in 2010. Apparently, this sector has been the major sector in creating employment opportunities. In 1970, employment in the manufacturing sector represented only 9.4 percent of total employment (Malaysia, 1976). In line with the industrialization process, the share of employment in the
manufacturing sector increased over the years. As at 2010, the share of employment in the sector has increased to 27.8 percent (Malaysia, 2010).

It is often the case that rapid expansion of manufacturing industries during economic expansion is associated with large employment of new workers and new technologies, machineries and equipments. While the application of new technologies would expose new hazards to the workers, hiring new worker might as well pose higher risk of accident as they are not accustomed to the hazard of workplace environment. Therefore, a study of workplace injuries in Malaysian manufacturing sector is particularly relevant since it would contribute to a greater understanding of factors that determine workplace injuries in the sector.

Workplace injuries have been the subject of growing number of academic research since the last three decades. However, large body of research focusing on the causes of injuries is dominated by empirical studies in industrialized countries, such as European countries and the U.S. In Malaysia, existing studies on workplace injuries were mainly focused on the issues of the establishment and enforcement of the Occupational Safety and Health Act (OSHA) and the evolution of safety related regulations (Jamaluddin, 1994; Rahmah and Sum, 2000; Mansur et al., 2003; Ariffin et al., 2006; Rampal and Nizam, 2006; Lugah et al., 2010; Surienty et al., 2011). Empirical study on workplace injuries in Malaysia, however are still lacking and mostly concentrated on the construction sector (Abdul Hamid et al., 2008; Ali et al., 2010; Zakaria et al., 2010). Apart from these studies, Mansor et al. (2011) examine the influence of individual factors and nature of job on accident among workers at port sites. However, to the best of our knowledge, no attempt has been made to specifically investigate factors that influence workplace injuries in Malaysian manufacturing industries. Hence, the objective of our study is to empirically examine factors that contribute to workplace injuries in Malaysian manufacturing industries during 1993-2008. We specify our empirical model based on two approaches, viz. the business cycle and structural approaches. Difficulties of obtaining data on wage premium and on employees’ protection measures for each industry prevent us from incorporating the labor market oriented approach in our model.

The remainder of this paper is structured as follows. Next section provides an overview of workplace injuries in Malaysia and followed by literature review. Subsequently, this study discusses the model specification and data, which is followed by results and discussion. Finally, this study concludes and offers some policy implications.

OVERVIEW OF WORKPLACE INJURIES IN MALAYSIA

Table 1 and Table 2 respectively present the number of industrial accidents by sectors and by types of accident in Malaysia during 1994-2008. There was significant decline in the total number of industrial accidents reported for all sectors, a decrease of 55.30 percent from 125,506 in 1994 to 56,095 in 2008. Among all sectors, the number of accidents reported for the manufacturing sector has been the highest throughout the period. This reflects workers in the manufacturing sector are exposed to higher accidental risks.

Table 1. Industrial Accidents Reported by Sectors, Malaysia, 1994 – 2008.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, Forestry and Fishing</td>
<td>27,268</td>
<td>24,390</td>
<td>13,293</td>
<td>8,796</td>
<td>5,739</td>
<td>3,962</td>
</tr>
<tr>
<td>Mining and Quarrying</td>
<td>1,406</td>
<td>763</td>
<td>643</td>
<td>736</td>
<td>541</td>
<td>368</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>68,281</td>
<td>37,829</td>
<td>42,915</td>
<td>33,901</td>
<td>27,066</td>
<td>19,041</td>
</tr>
<tr>
<td>Electricity, Gas, Water and Sanitary Services</td>
<td>588</td>
<td>372</td>
<td>592</td>
<td>513</td>
<td>515</td>
<td>524</td>
</tr>
<tr>
<td>Construction</td>
<td>4,536</td>
<td>3,648</td>
<td>4,966</td>
<td>5,113</td>
<td>4,500</td>
<td>3,814</td>
</tr>
<tr>
<td>Trading</td>
<td>9,173</td>
<td>9,248</td>
<td>15,472</td>
<td>13,576</td>
<td>11,783</td>
<td>11,342</td>
</tr>
<tr>
<td>Transportation</td>
<td>4,437</td>
<td>3,276</td>
<td>4,800</td>
<td>4,142</td>
<td>3,653</td>
<td>3,305</td>
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<tr>
<td>Financial Institution</td>
<td>592</td>
<td>367</td>
<td>7,293</td>
<td>6,195</td>
<td>5,386</td>
<td>718</td>
</tr>
<tr>
<td>Real Estates, Renting and Business Services</td>
<td>2,830</td>
<td>3,731</td>
<td>6,581</td>
<td>5,617</td>
<td>4,832</td>
<td>4,405</td>
</tr>
<tr>
<td>Total</td>
<td>125,506</td>
<td>89,049</td>
<td>98,281</td>
<td>81,003</td>
<td>68,008</td>
<td>56,095</td>
</tr>
</tbody>
</table>

Note: Total accident reported include total commuting accidents.
It can be observed that the pattern of accidents reported varies from one sector to another, reflecting the difference of hazard across sectors. As shown in Table 2, 20.60 percent of total fatal accidents and 37.91 percent of total disablement accidents in 2008 involved workers from the manufacturing sector. Although there has been significant reduction of total accident in the manufacturing sector, accident cases which caused fatality and disablement shown an increment. Between 1998 and 2008, fatal accidents increased from 256 to 268 cases, while disablement increased from 5,823 to 9,701 cases.

Table 2. Types of Accidents Reported by Sectors, Malaysia, 1998 and 2008.

<table>
<thead>
<tr>
<th>Sectors</th>
<th>Fatal Accidents</th>
<th>Disablement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, Forestry and Fishing</td>
<td>69</td>
<td>154</td>
</tr>
<tr>
<td>Mining and Quarrying</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>256</td>
<td>268</td>
</tr>
<tr>
<td>Electricity, Gas, Water and Sanitary Services</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>Construction</td>
<td>124</td>
<td>102</td>
</tr>
<tr>
<td>Wholesale and Retail Trade, Restaurant and Hotel</td>
<td>139</td>
<td>231</td>
</tr>
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<td>Transportation</td>
<td>83</td>
<td>121</td>
</tr>
<tr>
<td>Financial Institution</td>
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<td>16</td>
</tr>
<tr>
<td>Civil Service</td>
<td>109</td>
<td>114</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,135</td>
<td>1,301</td>
</tr>
</tbody>
</table>

Note: 1 Total includes fatal accidents and disablement from other services.

Figure 1 illustrates the trend of industrial accidents in the manufacturing sector reported from 1993 to 2008. Overall, total industrial accidents in the manufacturing sector were on a declining trend, except from 1998 to 2000 which shows an upward trend. An upward trend of industrial accidents during this period was attributable to Malaysian economic recovery from the Asian financial crisis which hit Malaysia in the middle of 1997. The upward and downward trend in total accidents during economic crisis and its recovery partly explain the influence of business cycle over industrial accidents. During economic crisis in 1997, firms tended to reduce both the volume and cost of production in response to decrease in aggregate demand. Reducing production involves the lay-off of newly hired, less experienced and unskilled workers who are normally more vulnerable to accident at the workplace. Hence by running the plants with the experienced and skilled workers during economic recession helps to reduce the number of accident cases reported.
Workplace injuries in Malaysian Manufacturing Industries

Source: Labour and Human Resources Statistics (various issues), Kuala Lumpur: Ministry of Human Resource.

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As the economy began to recover in 1998, there was an increase in employment due to increase in production. Increase in employment during economic upswing meant hiring new workers who are not accustomed to the hazards of their new jobs and hence increased the number of accidents reported. After 2000, total accidents in the manufacturing sector were steadily declined. This could be attributed to the remarkable improvement in the safety and health conditions in the workplace. The growing concern among the regulators and employers over the safety and health issues at workplace in Malaysia has led to the introduction of the comprehensive OSHA enacted in 1994 along its related regulations. The legislations that govern issues pertaining to occupational safety and health at the workplace in Malaysia are:

1. Factories and Machinery Act 1967;
2. Employees Social Security Act 1969;
3. Occupational Safety and Health Act 1994;
4. Occupational Safety and Health (Employer’s Safety and Health General Policy Statements) (Exception) Regulations 1995;
5. Occupational Safety and Health (Control of Industrial Major Accident Hazards) Regulations 1996;
6. Occupational Safety and Health (Safety and Health Committee) Regulations 1996;
7. Occupational Safety and Health (Classification, Packaging and Labeling of Hazardous Chemicals) Regulations 1997;
8. Occupational Safety and Health (Use and Standards of Exposure of Chemicals Hazardous to Health) Regulations 2000;

LITERATURE REVIEW
An early study on workplace injuries relates its structural nature to the business cycles. Kossoris (1938) was the first researcher who investigated the relationship between business cycle and workplace injuries for the U.S. manufacturing industry for the years 1929 through 1935. He showed that, in general, the trend of injuries frequency rate followed the trend of industrial employment thus provides an early indication of pro-cyclical behavior of workplace injuries towards business cycle. Studies by Cooke and Gautschi (1981), Viscusi (1986) and Robinson and Shor (1989) support the pro-cyclical relation showing that the number of injuries tends to increase during economic upswings and vice versa. An inference as to why injury rates increase during economic expansion is the increase in employment of new inexperienced workers in the workforce who are vulnerable to accident at their new workplace. A pattern of decrease in injury rates observed by Kossoris (1938) during the Great Depression was related to workers’ initiatives to report injuries. Workers tend to avoid reporting an injury, minor injuries in particular, in order to secure their position in the industry.

While the above studies support the pro-cyclical relation, a study on Finnish manufacturing and construction industries by Saloniemi and Oksanen (1998) during 1977 to 1991 however provides no evidence on the
relationship between fatal accidents and business cycle. Similarly, in a study of workplace injuries for the United Kingdom from 1986 to 2005 by Davies et al. (2009) found no significant relationship between business cycle and major injuries.

Oi (1974) analyses various aspects of workplace injuries in the U.S. including the characteristics of workers, labor turnover and establishment size. It appears that over all ages, males were three times as likely to be injured at work as females. As for labor turnover, an increase in the accession rate or new hires of less experienced workers during high employment gives rise to an increase in the overall work injury rates. Injury rates in relation to establishment size exhibit an inverted U-shaped where the smallest and the largest establishments reporting lower injury cases. Lower injury frequency in larger establishments could be explained by lower labor turnover, larger fractions of workers in safer tasks and fewer young males.

Smith (1979) estimates the impact of OSHA inspections on the U.S. manufacturing industry for the years 1972 to 1974. The study finds that injury as it pertains to inspection effect varies across plant-size and hazardous plant categories. Inspection effects were larger and statistically significant for the smallest plant and tend to be greater in the more dangerous plants. Similarly, Smith (1979) suggests that the relationship between firm size and injury rates probably is an inverted U-shaped. One possible explanation to the relationship is that small firms are less hazardous and easily monitored, while large firms, with the advantage of economies of scale are able to apply safety machineries and equipments.

Cooke and Gautschi (1981) examine the impact of OSHA citation activities and plant-specific programs upon changes in the injury rates for 113 Maine manufacturing plants over the period 1970-1976. Apart from OSHA citations, other factors included in the study are plant size and business cycle. The study employs the change in the percentage of production workers receiving first payments as a proxy measure of business cycle. They found that both firm size and business cycle were highly significant to injury rates. While firm size influences injury rates negatively, business cycle affects positively. They concluded that OSHA investigation activities have reduced the injury rates substantially for the case of larger firms.

Using a sample of 20 two-digit U.S. manufacturing industries from 1973 to 1983, Viscusi (1986) investigates the impact of OSHA on workplace safety. The independent variables included in the analysis are production workers, female workers and three variables to capture the influence of business cycle, namely the percentage change in the industry’s employment, average weekly work hours and average overtime hours. While production workers are found to be positively related to accidents, female workers showed the reverse effect. A positive relationship between business cycle and injury rates is only significant for percentage change in the industry’s employment. The results thus support for pro-cyclical relationship between employment and workplace injuries.

Currington (1986) analyses the impact of OSHA standards on injury frequency rates for 18 manufacturing industries in New York from 1964 to 1976. The analysis of the study is performed separately for “all injuries”, “caught in machine”, and “struck by machine” injuries. The independent variables included are unionization, capital intensity, firm size, new hire rate, employment ratio and production workers. All these variables are only significant for “all injuries” except the employment ratio, a proxy measure for cyclical variation. Among the significant variables, firm size is found to be the only variable which affects injury frequency negatively.

Jeong (1997) analyses the characteristics and causes of accidents for Korean manufacturing industry during 1991-1994. Analysis of causes of accidents in the study includes firm size, age and work experience. The analysis shows that larger companies tend to have a lower accident rates and adults and less experience workers are more prone to accidents. Fabiano et al. (2004) examine the relationship between workplace injuries and types of Italian industry during 1995-2000 with a large sample of 2,983,753 firms. They identify four major factors that influenced accident frequency, namely economical factors, technologies used, organizational factors and human factors and relate these factors to the firm size effect. An inverse relationship between accident frequency and firm size is found in all types of industries. The results of the study suggest that the four factors are unfavorable for small firms which prove to be more liable to high accident frequency.

Previous studies on workplace injuries in Malaysia are mainly focused on the evolution and enforcement of OSHA and level of awareness and knowledge on safety issue among employers and employees (Jamaluddin, 1994; Mansur et al., 2003; Ariffin et al., 2006; Rampal and Nizam, 2006; Lugah et al., 2010). As shown by their studies, safety and health regulations in Malaysia have evolved from very prescriptive legislations to detailed technical provisions and to the one that is more flexible where self-regulations are encouraged under OSHA 1994. Rahmah and Sum (2000) on the other hand, analyze the impact of OSHA on labor market demand in 50 manufacturing firms. The results of cross-sectional analysis of their study show that OSHA has a significant impact on the demand for labour by firms. The impact of OSHA is also different across types of industry where labor-intensive firms were found to be more sensitive towards the regulations. A recent study by Surienty et al. (2011) investigates the impact...
of demographical variables (company size, type of organization and years of establishment), management commitment, external support and legislation on Occupational Safety and Health (OSH) implementation in Small and Medium Enterprises (SMEs) in Malaysia. The correlation analysis performed on surveyed data of 35 companies shows that only management and external support were significant to OSH implementation where both variables have positive correlation.

Several studies have attempted to examine the causes of accidents in the construction sector in Malaysia (Abdul Hamid et al., 2008; Ali et al., 2010, Zakaria et al., 2010). Through analysis made on surveyed data, they show that the main causes of accidents at construction sites are workers’ negligence, failure to obey the work procedures, work at high elevation, operate equipments without safety devices, poor site management and low skill and knowledge. A study on accidents at port sites by Mansor et al. (2011) focuses on two common dimensions of workplace accidents, namely individual and job related factors. Using 177 surveyed samples, correlation test results show that stress and fatigue, unsafe action, machinery and tools, design of workplace, training procedures are the significant factors that contribute to workplace accidents.

MODEL SPECIFICATION AND DATA DESCRIPTION
This study analyzes factors that contribute to workplace injuries in 44 Malaysian manufacturing industries during the period from 1993 to 2008. The structure of our data set which contains both cross-sectional and time series satisfies the balanced panel data estimation technique. Using panel data, with a large number of data points and high degree of freedom helps to reduce the multi-collinearity problem (Hsiao, 2003). To identify which character of our data set belongs to, either fixed or random, the Hausman specification test is first performed. The test results suggest that the industry-specific effects are fixed and the general fixed-effects model is presented as follows:

\[ Y_{it} = \alpha_i + \beta_i X_{it} + \mu_{it} \]  

where \( Y_{it} \) is the dependent variable, \( i \) is entity, \( t \) is time, \( \alpha_i \) (\( i = 1 \ldots \cdot n \)) is the \( n \) entity-specific intercept, and \( \beta_i \) is the coefficient for independent variable, \( X_{it} \) and \( \mu_{it} \) is the error term. Based on the general fixed-effects model, we rewrite equation (1) into the following specification:

\[ IR_{it} = \alpha_i + \beta_1 \log S_{it} + \beta_2 \log KI_{it} + \beta_3 PW_{it} + \beta_4 FW_{it} + \beta_5 CV_{it} + \mu_{it} \]  

where:

- \( IR \) = the injury rate;
- \( S \) = the firm size;
- \( KI \) = the capital intensity;
- \( PW \) = the percentage of production workers in the industry;
- \( FW \) = the percentage of female workers in the industry;
- \( CV \) = the cyclical variation;
- \( \alpha \) = the industry-specific intercepts;
- \( \beta \) = the coefficient for each independent variable;
- \( \mu \) = the error term;
- \( i \) = industry;
- \( t \) = year

The injury rate, as a proxy for workplace injuries, is measured by the percentage of accidents reported per worker employed. Firm size is measured by employees per establishment and capital intensity is measured by the value of fixed assets per worker where these two independent variables take the natural logarithm form. Production workers and female workers are respectively measured as a percentage of total employment. The cyclical variation variable is measured by the percentage change of total employment in the manufacturing industries.

Most studies on workplace injuries and business cycle support the existence of pro-cyclical relationship where the number of accidents tends to increase during economic upswings and reduce during economic recession.
Workplace injuries in Malaysian Manufacturing Industries

(Kossoris, 1938; Leigh, 1985; Robinson and Shor, 1989). Thus, we expect a positive relationship between injury rates and cyclical variation. Similarly, capital intensity, production worker, and female worker are expected to have positive influence over the injury rates. As for firm size, a negative relationship with injury rate is expected in the sense that larger firms are better in controlling accidents among workers as compared to smaller firms (Cooke and Gautschi, 1981; McVittie et al., 1997).

Three types of workplace injuries are included in the study, viz. fatal accidents, permanent disability and temporary disability. Data on workplace injuries were obtained from Annual Report published by Social Security Organization (SOSCO). The Annual Survey of Manufacturing Industry, published by the Department of Statistics, provides data on total employees, fixed assets and total establishments for each industry. Unpublished data of production and female workers in manufacturing plants were obtained from the Department of Statistics.

Table 3 presents a summary of the descriptive statistics of the variables used in this study. During 1993-2008, the average injury rate among the sample manufacturing industries was approximately 3.90 percent ranging from a minimum of 0 to a maximum of 54.86 percent. The lowest and the highest injury rate came from tanneries and leather finishing industries and metal and wood working machinery manufacturing respectively. The average for firm size and capital intensity was 134.21 and 120.63 percent respectively. The mean for total production worker and female worker were 57.86 and 21.33 percent respectively. The average cyclical variation was 5.60 percent throughout the period of study.

Table 3. Descriptive Statistics.

<table>
<thead>
<tr>
<th>Variables</th>
<th>IR</th>
<th>S</th>
<th>KI</th>
<th>PW</th>
<th>FW</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>3.90</td>
<td>134.21</td>
<td>120.63</td>
<td>57.86</td>
<td>21.33</td>
<td>5.60</td>
</tr>
<tr>
<td>Median</td>
<td>1.99</td>
<td>75.80</td>
<td>73.76</td>
<td>65.06</td>
<td>17.40</td>
<td>3.06</td>
</tr>
<tr>
<td>Maximum</td>
<td>54.86</td>
<td>1399.63</td>
<td>1367.41</td>
<td>92.17</td>
<td>75.20</td>
<td>136.61</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.00</td>
<td>1.51</td>
<td>1.76</td>
<td>0.13</td>
<td>0.00</td>
<td>-83.87</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>5.50</td>
<td>202.49</td>
<td>174.46</td>
<td>21.26</td>
<td>18.20</td>
<td>23.65</td>
</tr>
</tbody>
</table>

RESULTS AND DISCUSSION

The results of fixed-effects estimation under two separate regressions are reported in Table 4. We treat Model 1 as the reference model. In Model 2, production workers (PW) is excluded to isolate the possible influence of this variable over female workers (FW) resulting from our measurement method.

The results of this study reveal a strong negative relationship between firm size (S) and injury rate (IR) as the sign of the coefficient and its level of significance are consistent under the two models. This finding is consistent with the theory (Oi, 1974; Smith, 1979) and supports the empirical findings of previous studies (Cooke and Gautschi, 1981; McVittie et al., 1997). It turns out that the larger the firm, the lower the injury rate. This could be attributed to a proper safety precaution practiced by larger firm or adoption of safety machinery and equipments.

The coefficient for capital intensity (KI) is positive, however, it is statistically insignificant in both models. Production workers (PW) and female workers (FW) are found to have positive influence over injury rate (IR) and both are significant at 5 percent level. Our finding with respect to production workers is consistent with Viscusi (1986). The result is justifiable as production workers are those who are directly involve in firms operation and having direct contact with machineries and equipments. Hence, increase in the fraction of production workers in manufacturing plants would increase the injury rate. In contrast, Viscusi (1986) found a negative relationship between female workers and industrial accidents where he expected that higher fraction of female workers involve less physical effort and pose lower risk. A positive sign of female workers in this study leads us to draw a number of inferences. A common explanation is to relate accident to the natural characteristics of women which physically are less capable of performing some tasks (Lin et al., 2008). Industrialization would normally result in increase participation of women in manufacturing industries and most of them are assigned the same tasks as performed by men. In addition, workplace and machinery designs are usually designed to fit male’s capacity (Taiwo et al., 2008). Hence, these factors would expose female workers to the similar risks faced by male workers, but the impact would be different as far as women physical anthropology is concerned.

Table 4. Fixed-effects Estimation Results.

<table>
<thead>
<tr>
<th>Explanatory Variables</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm Size (S)</td>
<td>-1.780</td>
<td>-1.876</td>
</tr>
</tbody>
</table>
Our result for business cycle (CV) impact on industrial accident is consistent with pro-cyclical relation in previous studies (Kossoris, 1938; Leigh 1985; Cooke and Gautschi, 1981; Robinson and Shor, 1989). The coefficient for cyclical variation remains positive and significant under the two different estimations, suggesting that business cycle is an important determinant of injury rate in Malaysian manufacturing industries.

**CONCLUSION AND POLICY IMPLICATION**

This paper sought to analyze the determinants of workplace injuries in Malaysian manufacturing industries during the period 1993 to 2008. Adopting the structural and business cycle approach, our panel data was tested using fixed-effects estimation method. The results of this study reveal that firm size, production workers, female workers and cyclical variation are the important factors for workplace injuries in Malaysian manufacturing industries. Our empirical findings, however, provide no evidence to support the effect arising from the level of capital intensity of manufacturing industries.

The most robust findings of this study are that workplace injuries were negatively influenced by firm size and positively influenced by cyclical variation. Consistent with previous studies, this study found that large manufacturing firms are more capable of controlling accidents at workplace as compared to small firms. This reflects greater level of awareness on OSH matters among large firms. Efforts by employers from SMEs in Malaysia in promoting safety and health in the workplace are still lacking (Rampal and Nizam, 2006) possibly due to low awareness over OSH requirements (Suriyinty et al., 2011). Under OSHA 1994 (Section 30), every employer shall establish a safety and health committee at the place of work if there are 40 or more persons employed. Lack of law enforcement on smaller firms is possibly the underlying factor that they are less sensitive towards OSH issues. Therefore, to improve safety at workplace in Malaysian manufacturing industries, higher priorities should as well be given to small firms through supplementary and special inspections to ensure that small firms apply the appropriate safety and health standards and codes of practices.

Similarly, focus of safety regulations should as well be given to reduce business-cycle-related injuries. Since business cycle is an unpredictable phenomenon, advanced preventive efforts towards potential accidents among workers during economic upswing might be useful to reduce accidental risks in industries. Preventive measures may include training programs and technical skills education. In Malaysia, there have been concerted efforts among government agencies to prepare the Malaysian youths with relevant skills, knowledge and experience through vocational and technical schools, polytechnics and industrial training institutions. On the employers’ side, hiring safety machineries and equipments as well as safety devices will further help to reduce the risks of getting injured at workplace.

The results of this study also reveal that production workers and female workers in manufacturing plant are equally significant for injury rates. It is generally known that production workers, either male or female, are those who directly perform the operation in the plants and have a direct contact with machinery and equipments. Poor working attitude, inadequate knowledge and experience, and poor supervision by the management are among the
factors that place them into accidental risks. Therefore, improved training programs and enforcement of compliant safety regulations should be the priorities by both the employees and employers.

This study has shown that workplace injuries in Malaysia are generally attributed to both business cycle and structural factors. Hence, it suggests the importance of OSHA enforcement and its compliance to codes of practices among manufacturing industries in Malaysia. Our study is limited by some measures which were not able to be included in the analysis, such as compensation, level of workers’ knowledge and experience and other relevant factors. We leave these limitations to be improved in future in-depth analysis.

REFERENCES


THE IMPACT OF RETURN TO WORK PROGRAMS ON THE HEALTH STATUS OF INJURED WORKERS WITH WORK-RELATED MUSCULOSKELETAL DISORDERS: A MALAYSIAN STUDY

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3. Occupational Therapy Division, School of Health and Rehabilitation Sciences, University of Queensland, Australia

Abstract

Introduction:
This study explores the health status of injured workers in return to work (RTW) programs based on their ability and capacity. Injured workers were diagnosed with work-related musculoskeletal disorders. The findings will help not only the service provider plan a specific strategy but also allow stakeholders to review their role in the RTW program.

Methods:
102 participants were chosen from a national RTW program, and categorized into three groups based on different phases of the RTW program: off-work (n=30, 29.4%), work re-entry (n=44, 43.1%) and maintenance (n=28, 27.5%). Self-report questionnaires identified demographic data, health surveillance via SF-36 and perceived physical and psychological workload by 10-point numerical scales. Analysis of variance (ANOVA) and Kruskal-Wallis Test was employed to examine the differences in three phases of the RTW program. Paired t-test analyzed the differences of related samples of physical and psychological workload before and after injuries.

Results: The domains of health status are below the average compared to the norm-based population. Mental health component summary is better than physical health. At the domain level, there are significant differences among injured workers, specifically in the three RTW program phases. The SF-36 domains are: role-physical, vitality, bodily-pain, general health, and mental health ($p < 0.049$). In contrast, non-significant differences were found in physical and social functioning, and role of emotion status. Moreover, their self-perceived physical and psychological work-load significantly worsened after injuries ($p < 0.020$).

Conclusions: The case manager-coordinated RTW program provided further opportunities to improve injured workers’ health status when looking at their differences for different phases of RTW. Other health professionals like occupational therapists, ergonomists and psychologists should become involved in the RTW program. Specific guidelines and regulations have to be implemented to ensure full participation with all parties in the workplace.

Keywords: Health status, return to work, phases and musculoskeletal disorders

Introduction

Work-related musculoskeletal disorders (MSDs) may develop over time or as the result of acute injuries, and are caused either by the work itself or the immediate environment [1-4]. Typically, MSDs affect people’s back, neck, shoulders and upper limbs, with lower limbs less often affected [5]. People with MSDs often experience a number of complications associated with their injury, for example pain, stress, anxiety and depression. A number of previous studies found that pain is one of the major impairments of MSDs [1, 6, 7]. Psychological symptoms such as anxiety, stress and depression also commonly affect workers who are absent from work for long periods [1, 6, 8, 9]. Furthermore, people who suffer work-related MSDs may experience physical restrictions in daily life activities which could further compromise their quality of life [1, 10-12]. Environmental barriers (e.g., poor workplace social culture or lack of family and workplace support) also increase considerably the stress and lower back pain experienced by the MSDs affected workers [13]. In addition, research has found that the workers who were absent from work for long periods experienced poor self-image or morale, changed life rhythms, as well as difficulties in carrying out daily life roles while attempting to return to work [13, 14]. Fear of rejection, anger, and isolation due to the inability to perform daily life duties and activities were also common psychological issues reported by injured workers [15].

Health status has been recently become a main concern in outcome measures for people with
MSDs. According to the World Health Organization (2006), health is defined as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” [16]. People with MSDs have significant variations in the extent and the nature of impairments and functional limitations, therefore, it is important to explore the concepts of health status based on self-reported perspectives. It is important to note, however, that self-ratings of health status are dependent on a person’s awareness and expectations about their health as well as health information and services available.

Return to work (RTW) programs involving a multi-disciplinary approach have been largely developed to assist in re-gaining working capacities and, importantly, health, quality of life or daily life roles in injured workers with work-related MSDs. The rehabilitation process is often long, depending not only on the provided services but also the support from stakeholders, including the employer, peers, family members and the wider community [17, 18]. The number of health professionals involved in the RTW program varies, and each health professional plays a different but important role in managing MSDs. In particular, occupational health physicians, psychologists, physiotherapists, occupational therapists, ergonomists, and case managers are vital in managing workers with MSDs [11, 12, 17-19].

The Malaysian context

The RTW program was introduced by the Social Security Organizations (SOCSO) in Malaysia for injured workers in accordance with the Employees’ Social Security Act 1969, Section 57(1). Malaysian citizens and permanent residents who are registered and contribute monthly to SOCSO are entitled to benefit from the protection scheme if they are injured or disabled in the course of their employment, including workplace or commuting accidents and occupational diseases. In early 2008, SOCSO adopted the bio-psychosocial RTW program model developed in several countries such as Australia, Canada, Sweden and the United States. The main objectives of the SOCSO RTW program are to improve quality of life, retain skilled workers in the workplace, and reduce compensation claim costs [20]. In 2009, SOCSO spent almost USD$219 million on temporary and permanent disablement benefits and invalidity pensions for injured workers. This cost increased considerably from USD$187 million in 2008 [20]. According to the SOCSO report, the number of workers who have had more than 100 days sick leave was 51,107 cases between 1996 and 2009 [21], with approximately 5,000 people accumulating sick leave of more than 100 days every year. The highest proportion (about one-third) of people with work-related injuries in 2009 was derived from the manufacturing area [21]. This scenario emphasizes why the establishment of a RTW program was necessary in Malaysia. The aim of the RTW program is to return injured workers to work safely and as soon as possible following rehabilitation, thus preventing further SOCSO cost blow-outs. However, the RTW program only began in early 2008 and its impact on health status of injured workers has not yet been explored.

Evaluations of RTW programs have to date focused on the workers’ overall health status (pain, psychological factors, specific functional disabilities, and quality of life), environmental factors (working hours and psychological and physical workload), work disabilities (sick leave, compensation and services providers costs ) and success rates for truly returning to work [11, 12, 17-19]. Most of these RTW outcomes were measured at 1, 2 or 5 years after those participants returned to work [10, 12, 22]. These studies mostly focused on injured workers at two key stages: the off-work phase or the return to work phase. None of the studies investigated the outcomes across the four different RTW program phases (Off-work, Work re-entry, Maintenance, and Advancement) described by Young et al. in 2005 [23]. It is important to provide empirical evidence for effective intervention based on the different considerations of different stages or phases of injury and return-to-work. This study therefore aimed to measure the self-reported health status (including physical and mental health components) across the four different RTW phases.

Aims and Objectives

Given that multi-disciplinary approaches led and coordinated by case managers have been shown to improve work disabilities as well as health status of injured workers [10, 12, 22], this study aimed to investigate health status of injured Malaysian workers with MSDs at different RTW program phases based on their abilities and capacities.

Specific objectives of this study were:
1. to identify the health status of workers with MSDs who are participating in Malaysian national RTW program;
2. to compare their health status by dividing them into different RTW phases; and
3. to compare the differences in their perceived physical and psychological workload before and after their injuries.

Methods

Subjects and procedures
A randomized stratified sampling strategy, based on body part injured, was used to ensure that the sample for this study included representative ratios of workers with different disabilities. Inclusion criteria were: (1) a current work-related MSD; (2) ability to read and understand the Malaysian Language; and (3) involvement in the SOCSO RTW program between early 2008 and the end of 2010.

Four hundred potential participants were identified using a randomized computer sequence from SOSCO’s database which includes records for a total of 997 injured workers. These identified participants received an official letter providing participation information sheets and a stamped envelope that can be used to return their written consent for participation. A total of 105 participants agreed to take part in the study as indicated by their consent form. They then received the SF-36 questionnaire [24] and a brief participant data survey that collected demographic, injury, treatment, and work-related information. In this survey, workers were also asked to categorize their current RTW status (by using the criteria described by Young et al. 2005) into one of the four phases (off-work, re-entry, maintenance, and advancement). As described by Young et al. 2005 the injured workers may move between phases in a non-linear fashion. Some of the injured worker probably has experienced one or more phases of RTW phases, or due to recurrent injuries they returned back to off-work phase, in this study, they only have to choose only one phase that best describe their RTW status recently. These criteria were:

Phase Off-work:
You are off work due to your MSDs injuries. You are at no time during this phase back at work, either in pre-injury or in an alternative capacity, and are still receiving medication and rehabilitation. During this phase, you are being assessed for functional abilities, employment-seeking behaviors and motivation to return to work.

Phase Re-entry:
You are just commencing your work. You have been given a modified task, time off, or a job which has different requirements to reduce your pain. While you are working, you may experience recurrent symptoms or disabilities (for example pain, restricted activity, physical and mental functioning limitations) which may have caused you to take time off from normal working hours.

Phase Maintenance:
You are continuing to work at your previous capacity ability. You are able to perform duties satisfactorily. You are able to achieve productivity levels or goals over the long-term, and demonstrate potential for advancement.

Phase Advancement:
You are able to improve your work responsibilities and increase remuneration levels. You are able to further your personal career development. You may have been chosen to undertake educational programs and are pursuing short- and long-term career goals.

In addition, the participants were asked to rate their perceived physical and psychological workload; when they re-entering to their actual employment (return to work), before and after injures, using a 10-point numerical scale, with 0 as not strenuous at all and 10 as very strenuous. Once completed, participants were required to return all survey forms and questionnaires by post. Telephone reminders were given at 14 days after the forms and questionnaires were sent.

Instruments

The SF-36 is a self-report questionnaire to measure the overall health status by understanding the effects of the disorders or illnesses on activity limitations and participation restrictions. There are eight domains regarding physical and mental health, and each domain consists of 2 to 10 items that are related. The 8 domains are physical functioning (10 items), role-physical (4 items), bodily-pain (2 items), general health (5 items), vitality (4 items), social functioning (2 items), role-emotional (3 items) and mental-health (5 items) [24]. For each item, variations of 3 to 6 point scale are used and a sum score can be calculated for each domain. In addition, the physical component summary
comprised physical functioning, role-physical, bodily-pain and general health domains. The mental component summary comprised vitality, social functioning, role-emotional and mental-health domains. The SF-36 has been culturally adapted and translated to the Malaysian language, and its validity and reliability were reported [25].

Ethics

Ethical approval was obtained from the Monash University Human Research Ethics Committee as well as the SOCSO prior to the study being conducted.

Statistical analysis

The analysis of this study began with descriptive analysis of the SF-36 in all participants and the separate groups by different RTW phases. A two sided p value <0.05 was considered statistically significant for the groups’ differences using one-way analysis of variances (ANOVA). The Shapiro-Wilk Test was used to test the normal distribution of the SF-36 scores [26]. One-way ANOVA and Kruskal-Wallis Test (depending whether the scores were normally distributed) were used to examine the difference of the SF-36 scores (at both the sub-scale and component level) among the injured workers at different RTW phases [27]. The Levene statistics prior to the ANOVA, was used to examine the homogeneity of the SF-36 scores [27]. In addition, a paired t-test was employed to analyse the differences regarding the participants’ physical and psychological workload before and after injuries [27]. All statistical analyses were performed using the Statistical Package for Social Sciences, Version 18 (SPSS, SPSS Inc, Chicago, IL) software.

Results

A total of 105 injured workers participated in this study, and the numbers in the different phases were: Off-work (n= 30, 28.6%), Re-entry (n= 44, 41.9%), Maintenance (n= 28, 26.7%), and Advancement (n=3, 2.8%). Since the Advancement group included only three participants, this phase was eliminated from the analysis of this study due to low statistical power. The limited size of this group was expected given that the SOCSO RTW program had been established only recently [21].

The characteristics of the participants included in this study are reported in Table 1. Overall, male participants with a Malay ethnicity were the dominant group and the majorities were aged 26-35 years. The most common location of injury was in the lower limb (31.4%). Physiotherapy (44.1%) was the main rehabilitation service provided, and the majority of employees worked for large companies (44.1%). The main occupation groups were lorry/taxi drivers and dispatch riders (31.4%) and factory workers (28.4%). In addition, there were non-significant differences (p = 0.107) in the number of injured workers among the three RTW program phases (i.e. off-work, work re-entry and maintenance). However, significant differences were found in relation to gender, age, ethnicity, location of injury, types of work, and types of employer (p < 0.001). In addition, by using one-sample t-test there was a statistically significant difference in sick leave days (mean = 207.3 ± 208.2, p <0.001) in the total of participating workers. Their working days before the injuries was also significantly different (mean = 3,170.2 ± 3,122.1, p <0.001).

Table 1. Characteristics of participants at different phases in the study

<table>
<thead>
<tr>
<th>Characters</th>
<th>Total (n=102)</th>
<th>Phase 1 (n=30)</th>
<th>Phase 2 (n=44)</th>
<th>Phase 3 (n=28)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender, n (%)</td>
<td></td>
<td>----------------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Male</td>
<td>84 (82.4)</td>
<td>25 (83.3)</td>
<td>33 (75.0)</td>
<td>26 (92.9)</td>
</tr>
<tr>
<td>Female</td>
<td>18 (17.6)</td>
<td>5 (16.7)</td>
<td>11 (25.0)</td>
<td>2 (7.1)</td>
</tr>
<tr>
<td>Age, n (%)</td>
<td></td>
<td>----------------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td>18 to 25 years</td>
<td>22 (21.6)</td>
<td>5 (16.7)</td>
<td>7 (15.9)</td>
<td>10 (35.7)</td>
</tr>
<tr>
<td>26 to 35 years</td>
<td>32 (31.4)</td>
<td>10 (33.3)</td>
<td>13 (29.5)</td>
<td>9 (32.1)</td>
</tr>
<tr>
<td>Age Group</td>
<td>n</td>
<td>(%)</td>
<td>n</td>
<td>(%)</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----</td>
<td>------</td>
<td>-----</td>
<td>------</td>
</tr>
<tr>
<td>36 to 45 years old</td>
<td>29</td>
<td>(28.4)</td>
<td>11</td>
<td>(36.7)</td>
</tr>
<tr>
<td>46 to 55 years old</td>
<td>17</td>
<td>(16.7)</td>
<td>3</td>
<td>(10.0)</td>
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<tr>
<td>56 years old and above</td>
<td>2</td>
<td>(2.0)</td>
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<td>(3.3)</td>
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**Ethnicity, n (%)**

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>n</th>
<th>(%)</th>
<th>n</th>
<th>(%)</th>
<th>n</th>
<th>(%)</th>
<th>n</th>
<th>(%)</th>
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</thead>
<tbody>
<tr>
<td>Malay</td>
<td>57</td>
<td>(55.9)</td>
<td>15</td>
<td>(50.0)</td>
<td>26</td>
<td>(59.1)</td>
<td>16</td>
<td>(57.1)</td>
</tr>
<tr>
<td>Chinese</td>
<td>17</td>
<td>(16.7)</td>
<td>5</td>
<td>(16.7)</td>
<td>8</td>
<td>(18.2)</td>
<td>4</td>
<td>(14.3)</td>
</tr>
<tr>
<td>Indian</td>
<td>23</td>
<td>(22.5)</td>
<td>9</td>
<td>(30.0)</td>
<td>8</td>
<td>(18.2)</td>
<td>6</td>
<td>(21.4)</td>
</tr>
<tr>
<td>Others</td>
<td>5</td>
<td>(4.9)</td>
<td>1</td>
<td>(3.3)</td>
<td>2</td>
<td>(4.5)</td>
<td>2</td>
<td>(7.1)</td>
</tr>
</tbody>
</table>

**Location of the injury, n (%)**

<table>
<thead>
<tr>
<th>Location</th>
<th>n</th>
<th>(%)</th>
<th>n</th>
<th>(%)</th>
<th>n</th>
<th>(%)</th>
<th>n</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>4</td>
<td>(3.9)</td>
<td>1</td>
<td>(3.3)</td>
<td>2</td>
<td>(4.5)</td>
<td>1</td>
<td>(3.6)</td>
</tr>
<tr>
<td>Neck</td>
<td>2</td>
<td>(2.0)</td>
<td>0</td>
<td>(0.0)</td>
<td>2</td>
<td>(4.5)</td>
<td>0</td>
<td>(0.0)</td>
</tr>
<tr>
<td>Trunk</td>
<td>25</td>
<td>(24.5)</td>
<td>7</td>
<td>(23.3)</td>
<td>12</td>
<td>(27.3)</td>
<td>6</td>
<td>(21.4)</td>
</tr>
<tr>
<td>Upper Limb</td>
<td>19</td>
<td>(18.6)</td>
<td>7</td>
<td>(23.3)</td>
<td>6</td>
<td>(13.6)</td>
<td>6</td>
<td>(21.4)</td>
</tr>
<tr>
<td>Lower Limb</td>
<td>32</td>
<td>(31.4)</td>
<td>6</td>
<td>(20.0)</td>
<td>13</td>
<td>(29.5)</td>
<td>13</td>
<td>(46.4)</td>
</tr>
<tr>
<td>Multiple injuries</td>
<td>20</td>
<td>(19.6)</td>
<td>9</td>
<td>(30.0)</td>
<td>9</td>
<td>(20.4)</td>
<td>2</td>
<td>(7.1)</td>
</tr>
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</table>

**Type of services obtained, n (%)**

<table>
<thead>
<tr>
<th>Type of Services</th>
<th>n</th>
<th>(%)</th>
<th>n</th>
<th>(%)</th>
<th>n</th>
<th>(%)</th>
<th>n</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medication or surgery</td>
<td>20</td>
<td>(19.6)</td>
<td>10</td>
<td>(33.3)</td>
<td>5</td>
<td>(11.4)</td>
<td>5</td>
<td>(17.9)</td>
</tr>
<tr>
<td>Physiotherapy</td>
<td>45</td>
<td>(44.1)</td>
<td>10</td>
<td>(33.3)</td>
<td>28</td>
<td>(63.6)</td>
<td>7</td>
<td>(25.0)</td>
</tr>
<tr>
<td>Occupational Therapy</td>
<td>3</td>
<td>(2.9)</td>
<td>2</td>
<td>(6.7)</td>
<td>1</td>
<td>(2.3)</td>
<td>0</td>
<td>(0.0)</td>
</tr>
<tr>
<td>Combination of the above</td>
<td>20</td>
<td>(19.6)</td>
<td>4</td>
<td>(13.3)</td>
<td>7</td>
<td>(15.9)</td>
<td>9</td>
<td>(32.1)</td>
</tr>
<tr>
<td>None of the above</td>
<td>14</td>
<td>(13.7)</td>
<td>4</td>
<td>(13.3)</td>
<td>3</td>
<td>(6.8)</td>
<td>7</td>
<td>(25.0)</td>
</tr>
</tbody>
</table>

**Type of occupation, n (%)**

<table>
<thead>
<tr>
<th>Type of Occupation</th>
<th>n</th>
<th>(%)</th>
<th>n</th>
<th>(%)</th>
<th>n</th>
<th>(%)</th>
<th>n</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office work</td>
<td>15</td>
<td>(14.7)</td>
<td>3</td>
<td>(10.0)</td>
<td>10</td>
<td>(22.7)</td>
<td>2</td>
<td>(7.1)</td>
</tr>
<tr>
<td>Labor work</td>
<td>12</td>
<td>(11.8)</td>
<td>6</td>
<td>(20.0)</td>
<td>4</td>
<td>(9.1)</td>
<td>2</td>
<td>(7.1)</td>
</tr>
<tr>
<td>Technical work</td>
<td>14</td>
<td>(13.7)</td>
<td>4</td>
<td>(13.3)</td>
<td>4</td>
<td>(9.1)</td>
<td>6</td>
<td>(21.4)</td>
</tr>
<tr>
<td>Factory work</td>
<td>29</td>
<td>(28.4)</td>
<td>6</td>
<td>(20.0)</td>
<td>12</td>
<td>(27.3)</td>
<td>11</td>
<td>(39.3)</td>
</tr>
<tr>
<td>Other than above</td>
<td>32</td>
<td>(31.4)</td>
<td>11</td>
<td>(36.7)</td>
<td>14</td>
<td>(31.8)</td>
<td>7</td>
<td>(25.0)</td>
</tr>
</tbody>
</table>

**Type of employer, n (%)**

<table>
<thead>
<tr>
<th>Type of Employer</th>
<th>n</th>
<th>(%)</th>
<th>n</th>
<th>(%)</th>
<th>n</th>
<th>(%)</th>
<th>n</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Company</td>
<td>23</td>
<td>(22.5)</td>
<td>3</td>
<td>(10.0)</td>
<td>13</td>
<td>(29.5)</td>
<td>7</td>
<td>(25.0)</td>
</tr>
<tr>
<td>Medium-sized Company</td>
<td>26</td>
<td>(25.5)</td>
<td>10</td>
<td>(33.3)</td>
<td>9</td>
<td>(20.4)</td>
<td>7</td>
<td>(25.0)</td>
</tr>
<tr>
<td>Large Company</td>
<td>45</td>
<td>(44.1)</td>
<td>11</td>
<td>(36.7)</td>
<td>21</td>
<td>(47.7)</td>
<td>13</td>
<td>(46.4)</td>
</tr>
<tr>
<td>Other than above</td>
<td>8</td>
<td>(7.8)</td>
<td>6</td>
<td>(20.0)</td>
<td>1</td>
<td>(2.3)</td>
<td>1</td>
<td>(3.6)</td>
</tr>
</tbody>
</table>
The Impact of Return to Work Programs on the Health Status of Injured Workers with Work-Related Musculoskeletal Disorders: A Malaysian Study

Overview of the SF-36 sub-scales and physical/mental components summary in all participants

Table 2 shows the overall mean scores of the SF-36 sub-scales and physical and mental component summary. All mean scores of the SF-36 sub-scales and physical and mental components summary were found to be significantly lower than the average score of the norm-based scoring (p < 0.001) [28]. The highest mean scores (i.e., better functions) for this sample were in the vitality (VT) sub-scale. The mental health component summary mean scores were also higher than the mean scores for the physical component summary. Subsequent analysis was made to test the normality of the mean scores. We found that all the overall mean scores of the SF-36 sub-scales and physical and mental component summary were normally distributed based on Shapiro-Wilk Test (p > 0.05) except for social functioning (SF), role of emotion (RE) and mental health (MH).

### Table 2. Overall mean scores of the subscales and physical and mental components summary of the SF-36

<table>
<thead>
<tr>
<th>SF-36 subscale/ Component summary</th>
<th>Mean (SD)</th>
<th>p-value</th>
<th>95 % Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical functioning (PF)</td>
<td>35.68 (9.44)</td>
<td>&lt;0.001</td>
<td>-16.80 – (-11.85)</td>
</tr>
<tr>
<td>Role physical (RP)</td>
<td>36.12 (9.03)</td>
<td>&lt;0.001</td>
<td>-16.27 – (-11.50)</td>
</tr>
<tr>
<td>Bodily pain (BP)</td>
<td>35.67 (8.47)</td>
<td>&lt;0.001</td>
<td>-16.54 – (-12.12)</td>
</tr>
<tr>
<td>General health (GH)</td>
<td>40.26 (9.56)</td>
<td>&lt;0.001</td>
<td>-12.26 – (-7.21)</td>
</tr>
<tr>
<td>Vitality (VT)</td>
<td>43.38 (9.59)</td>
<td>&lt;0.001</td>
<td>-9.13 – (-4.11)</td>
</tr>
<tr>
<td>Social functioning (SF)</td>
<td>39.56 (9.75)</td>
<td>&lt;0.001</td>
<td>-13.00 – (-7.89)</td>
</tr>
<tr>
<td>Role of emotion (RE)</td>
<td>33.75 (12.12)</td>
<td>&lt;0.001</td>
<td>-19.44 – (-13.05)</td>
</tr>
<tr>
<td>Mental health (MH)</td>
<td>37.58 (10.87)</td>
<td>&lt;0.001</td>
<td>-15.27 – (-9.56)</td>
</tr>
<tr>
<td>PCS</td>
<td>37.77 (7.69)</td>
<td>&lt;0.001</td>
<td>-14.27 – (-10.19)</td>
</tr>
<tr>
<td>MCS</td>
<td>38.98 (11.11)</td>
<td>&lt;0.001</td>
<td>-13.96 – (-8.07)</td>
</tr>
</tbody>
</table>

Note: 
PCS=Physical component summary, MCS=Mental component summary. Results are compared to norm-based scoring (each scale score mean =50.00 SD10) [28]

Comparison of mean scores on the SF-36 sub-scales and physical and mental components summary across the three RTW program phases

Given that the physical functioning (PF), role physical (RP), bodily pain (BP), general health (GH), vitality (VT), physical component summary (PCS) and mental component summary (MCS) were normally distributed, parametric statistics were used for analysis. The Levene statistic indicated that the variances for each sub-scale were homogenous. A subsequent analysis using one-way ANOVA was thus used to compare the SF-36 results in the three phases of RTW program. The results of the ANOVA found that four sub-scales (RP, BP, GH and VT) of the SF-36 exhibited significant differences between the groups based on the phase of the RTW program. There were no significant differences between the other sub-scales (physical functioning). Furthermore, their physical and mental summary scores were found to have no significant variations among the different phases of the RTW program.

Since the social functioning (SF), role of emotion (RE) and mental health (MH) were not normally distributed, the Kruskal-Wallis Test was used. Only MH was found to exhibit significant differences between the groups of injured workers at different phases of the RTW program. There were no significant differences between the other 2 sub-scales (SF and RE). Details of the results of the ANOVA and Kruskal-Wallis tests are summarized in Table 3.

Perceived physical and psychological workloads before and after the injuries

In terms of perceived physical and psychological work-load we found that, in the overall sample, there were significant differences between the participants’ ratings of their workloads (both physical and psychological) before and after injury. Similar results with the injured workers in the Phase Off-work was found (this is likely to reflect those workers who attempted work Re-entry but this was not successful, and they moved back to the Off-work phase). However, only psychological

<table>
<thead>
<tr>
<th>Sick leave, days (mean ±SD)</th>
<th>207.2±208.2</th>
<th>327.89±286.88</th>
<th>163.0±139.7</th>
<th>152.2±151.1</th>
</tr>
</thead>
</table>
workload demonstrated significant increases post-injury with the participants in the Re-entry and Maintenance phases. Details of the results are shown in Table 4.

Discussion

This study, using a sample of Malaysian workers with MSDs, is the first to investigate the differences in injured workers’ health status across Young’s different phases (off-work, work re-entry and maintenance). We found that all the SF-36 sub-scales and physical/mental summary components of the injured workers attending the SOCSO RTW program were below average compared to the internationally-established normative population. Their physical component summary was also found to be lower than mental component summary. Moreover, by dividing them based on different phases of the SOCSO’s RTW program, the five sub-scales of health status, i.e. role-physical (RP), bodily-pain (BP), general health (GH), vitality (VT) and mental health (MH), exhibited significant differences between groups. This indicates that the health status of the injured workers in some areas may improve as they regain considerable capacity and ability while progressing to higher phases in RTW program.

The MH, RP, BP, GH and VT statuses were improved significantly, probably because the workers recovered from their injuries or they were given light duties to reduce physical demands when they returned to work. This may also be the result of therapy received (such as Physiotherapy) as this treatment primarily focuses on improving injured workers’ pain and physical abilities. It was thus expected that any significant changes would be similar to those reported in another previous study [29], where physical training that included aerobic capacity, muscle strength and endurance supervised by physiotherapists had a positive effect on physiological outcomes and functional status of job demand [29].

The most significant gains were in the mental health (MH) status scores as participants returned to work and carried on with their usual duties. This may be the result of the support and services provided or funded by SOCSO and reduced financial concerns during sick leave due to the payment of temporary disablement benefits. Injured workers may also have received additional support from family, relatives, peers and employers when they re-entered to workplace or maintained their work. Previous studies found that sick leave without financial and family, peer and employer support caused more stress, depression and anxiety among injured workers [13, 30]. Therefore, mental health support can be considered as a potential benefit of RTW programs conducted by Malaysian’s SOCSO.

Physical functioning (PF) did not show significant improvement across the three phases of the RTW program included in this study. This may be explained by the fact that many participants had disabilities in lower limb (31.4%) and trunk (24.5%), and previous studies have shown that people who suffered injuries in these regions experienced a greater impact on their PF with a higher probability of permanent disability [31-34]. Moreover, in the current study they reported that their PF was greatly affected, especially in the items requiring a high degree of mobility or manual handling. 71.3% reported many limitations with vigorous and moderate activity and walking more than half a mile. In addition, 38.4 to 51.0% injured workers reported having some limitation in terms of lifting or carrying groceries, climbing several stairs, bending, kneeling, stooping and walking (100 yards). The majority of participants worked as factory workers, lorry or taxi drivers and dispatch riders, and therefore they would experience more impact on their day-to-day functioning, especially as their jobs involved greater physical demands and multi-tasking, resulting in little or slow improvement in their PF.

In this study, we found that participants’ ratings of their physical and psychological workload increased significantly after the injuries. Moreover, injured workers at Phase Off-work faced similar experienced with their physical and psychological workload. In contrast, only psychological workload increased significantly with injured workers once progressing to Phase Re-entry and Phase Maintenance. One explanation for this may be that workplace tasks or equipment were not modified or changed so that their PF level was still viable. Such changes would be expected if health professionals, such as occupational therapists or ergonomists, were involved in providing such environmental adaptation of changes. Other published studies demonstrated that such professional involvement in the RTW program reduced the recurrence of injuries and restored injured workers’ functional capacity and ability; therefore, this may help improve PF for injured workers [10, 35, 36].

Non-significant changes were reported for the social functioning (SF) of injured workers when they returned to work or achieved a maintenance standard. This may be explained by having only limited time as they progressed due to the demands of their workplace necessitating more responsibilities. Moreover, in this study we found that their psychological workload increased significantly after their injuries or while they were in different phases of RTW program. Perhaps, it could be also related to isolation or withdrawal as the result of their limited physical functioning. Therefore, improvement of their SF statuses needs to be taken into account further in the different
phases of RTW program.

Non-significant changes also occurred regarding the role of emotion (RE) sub-scale. Emotional problems, such as depression or anxiety, must be taken into account because it affects overall well-being of participants, either as workers or family members. Our results (i.e., about one third of the injured workers from current total population (N=102) reported lower scores in two RE items) further confirmed that they may be facing emotional problems while re-entering to their workplace. It was likely that the time they had for doing their regular daily activities was reduced and that they were not doing their work as carefully as usual. Other studies also pointed out that fear of rejection, anger and isolation due to the inability to perform regular duties and leisure activities, were common psychological issues experienced by injured workers with MSDs [15, 37].

Some global political and cultural issues could provide additional plausible reasons for non-significant changes of the PF, SF and RE sub-scales. For example, the employer may be involved only in a limited way and provided the worker with minor modification or adaptation of their workplace or duties based on a worker’s capacity and ability. The support for this argument is based on the fact that, although Malaysia has several statutory Acts such as the Employees’ Social Security Act 1969, Occupational Safety and Health Act 1984 and Disability Act 2008, there are no guidelines and regulations that specifically focus on occupational rehabilitation management (management of the return to work). This contrasts with countries such as Australia, which has clear guidelines such as the Victorian WorkCover Authority’s WorkSafe program which, in conjunction with The Accident Compensation Act (1985), has been developed to regulate employers and health providers in dealing with injured workers with RTW issues. These guidelines stipulate that, in a situation where a worker has sick leave (no current work capacity) for 20 or more calendar days, it is mandatory that the risk management program and an occupational rehabilitation team be established to plan strategically for the injured workers to return to work safely [11, 38, 39]. The mean sick leave of the injured workers in this current study (207.2 days) was 10 times longer than the above guideline with those in the Off-work phase having a mean 327.89 sick days. Previous studies have demonstrated that the longer workers were away from work, the more likely they were to report psychological symptoms and poor self-image [14]. Alternatively, the type of intervention may not have been optimized. Previous studies have shown that people with MSDs not only report physical but also psychological symptoms and disturbances regarding occupational lifestyle issues [1, 6-9, 15]. Engaging other healthcare providers earlier in the RTW phase would strengthen the RTW process. Management of stress, psychological support, occupational lifestyle modifications and workplace adaptation is the domain of healthcare professionals, for example occupational therapists, psychologists, counselors and ergonomists [10, 40].

The present study had several limitations. First, the generalizability of the current study was limited since only a small proportion (10.5%) of the participants were recruited from the entire population attending the SOCSO RTW program. Second, this study was conducted in Malaysia and the results can only be applied in this cultural and economic context. More research involving cross-cultural comparisons should be done in the future. Third, this study was unable to recruit a large enough sample of participants in the Advancement phase as the Malaysian RTW program has not been going long enough for people to reach this stage. Finally, the SF-36 comprises information specific to functionality and wellbeing. Future studies are needed to explore other factors or outcomes, such as how well people are able to adjust or adapt to their new occupational lifestyle through modifications or adaptations in their routines, roles and activities across different phases of the RTW program.

Conclusion

Overall, the findings of this study indicate that SOCSO’s RTW program may provide further opportunities for improving the health status of injured workers across different phases of the RTW program (off-work, work re-entry, and maintenance). Greater attention is needed with injured workers who have different capacities and abilities, especially in relation to physical emotional and social functioning. The findings suggest that involving multidisciplinary healthcare providers such as occupational therapists, ergonomists and psychologists may be needed to ensure that injured workers experience improved health and can return to work. Furthermore, it is suggested that rules and guidelines regarding occupational rehabilitation management be further developed and enforced. This would lead to increased awareness of the importance of securing the full participation of injured workers, case managers, healthcare providers and employers.

Acknowledgement

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References


Cochrane Database of Systematic Reviews 1999.


Table 3. The differences in scores on the sub-scales of the SF-36 between the group of injured workers in Phase Off-work, Phase Re-entry and Phase Maintenance

<table>
<thead>
<tr>
<th>SF-36 Subscale/Phase</th>
<th>Phase Off-work</th>
<th>Phase Re-entry</th>
<th>Phase Maintenance</th>
<th>Test statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical functioning (PF)</td>
<td>34.59 (10.25)</td>
<td>35.86 (8.48)</td>
<td>36.62 (10.23)</td>
<td>F = 0.33</td>
<td>0.718</td>
</tr>
<tr>
<td>Role physical (RP)</td>
<td>33.20 (9.38)</td>
<td>36.11 (8.38)</td>
<td>39.63 (8.77)</td>
<td>F = 3.65</td>
<td>0.030</td>
</tr>
<tr>
<td>Bodily pain (BP)</td>
<td>34.66 (7.27)</td>
<td>34.22 (8.03)</td>
<td>38.40 (9.60)</td>
<td>F = 3.14</td>
<td>0.048</td>
</tr>
<tr>
<td>General health (GH)</td>
<td>37.40 (9.05)</td>
<td>40.60 (8.74)</td>
<td>42.32 (11.47)</td>
<td>F = 3.12</td>
<td>0.049</td>
</tr>
<tr>
<td>Vitality (VT)</td>
<td>39.72 (9.25)</td>
<td>43.38 (9.38)</td>
<td>47.12 (9.82)</td>
<td>F = 4.35</td>
<td>0.016</td>
</tr>
<tr>
<td>Social functioning (SF)</td>
<td>38.72 (10.30)</td>
<td>38.76 (9.24)</td>
<td>43.08 (10.11)</td>
<td>H = 4.23</td>
<td>0.121</td>
</tr>
<tr>
<td>Role of emotion (RE)</td>
<td>31.42 (12.74)</td>
<td>33.88 (12.85)</td>
<td>37.03 (10.38)</td>
<td>H = 3.09</td>
<td>0.213</td>
</tr>
<tr>
<td>Mental health (MH)</td>
<td>35.12 (12.29)</td>
<td>36.37 (9.70)</td>
<td>43.34 (9.66)</td>
<td>H = 8.37</td>
<td>0.015</td>
</tr>
<tr>
<td>PCS</td>
<td>36.08 (8.34)</td>
<td>38.11 (6.66)</td>
<td>39.08 (9.08)</td>
<td>F = 1.36</td>
<td>0.261</td>
</tr>
<tr>
<td>MCS</td>
<td>36.78 (11.67)</td>
<td>38.33 (11.09)</td>
<td>43.85 (9.99)</td>
<td>F = 2.90</td>
<td>0.060</td>
</tr>
</tbody>
</table>

Note: PCS=Physical component summary, MCS=Mental component summary, F indicates that the analysis was performed by one-way ANOVA, H indicates that the analysis was performed by Kruskal-Wallis.

Table 4. Differences between participants’ ratings of physical and psychological workloads before and after injuries.

| | Before injury | After injury | Paired differences | CI |
|------------------------------------------|----------------|-------------------|---------|
| Total participants (n=102) | 4.78 (3.08) | 5.81 (2.67) | -1.03 (4.27) | -1.90-0.16 0.020 |
| Physical work load | 3.94 (3.26) | 6.42 (3.22) | -2.48 (5.08) | -4.58-0.38 0.022 |
| Psychological workload | 2.86 (2.95) | 7.74 (2.20) | -4.88 (3.49) | -6.39-(-1.69) <0.001 |
| Phase Off-work (n=25) | 3.98 (3.08) | 6.37 (2.45) | -2.40 (3.43) | -3.10-(-1.69) <0.001 |
| Physical work load | 3.12 (12.29) | 6.42 (3.22) | -3.28 (5.08) | -4.58-0.38 0.022 |
| Psychological workload | 3.98 (3.08) | 6.37 (2.45) | -2.40 (3.43) | -3.10-(-1.69) <0.001 |
| Phase Re-entry (n=42) | 5.11 (3.05) | 5.68 (2.52) | -0.57 (4.00) | -1.82-(-0.67) 0.358 |
| Physical work load | 4.03 (2.29) | 5.56 (2.30) | -1.39 (2.91) | -2.52-0.27 0.018 |
| Psychological workload | 3.12 (12.29) | 6.42 (3.22) | -3.28 (5.08) | -4.58-0.38 0.022 |
| Phase Maintenance (n=28) | 5.03 (2.92) | 5.46 (2.34) | -0.44 (3.68) | -1.86-(-0.99) 0.537 |
| Physical work load | 4.03 (2.29) | 5.56 (2.30) | -1.39 (2.91) | -2.52-0.27 0.018 |
SIMULATOR SICKNESS: A THREAT TO SIMULATOR TRAINING

Rabihah Ilyas

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Abstract

Rapid development of technology has made simulator as a promising training tool. Advantages offered such as interactive and realistic training environments, mistake tolerance and training in hazardous scenario without causing harm to trainee, cost effectiveness, opportunity of training review and training time flexibility makes simulator widely used in aviation training, driver training, medical training and rehabilitation. Despite of these advantages, a major drawback of simulator is simulator sickness. Simulator sickness is a condition caused by inconsistency perceived by our vestibular system. Effected individual reported that they are experiencing nausea, fatigue, postural instability, headaches and difficulty in focusing which linger for hours or days in some cases. This paper will discuss the simulator usage and simulator sickness condition in Malaysia as experienced by researchers and a few organizations that use simulator as their training tool.

Introduction

Training is essential in determining competitiveness of an organization as training supplies knowledge, skill and attitude required by organization. Training also be regarded as crucial in safety perspective which make it outlined as one of employer’s responsibility in OSHA 1994 (Occupational Safety and Health Act, Act 514, 1994. Regulation and Order, 1998). On job training is one of the most effective and simple method in knowledge and skill transfer. With learning by doing motto, the beginner and intermediate employees can really earn the benefit of training since they’ll be trained in actual working environment. Rapid development of technologies make simulator as one of promising on job training tool. Simulators offer interactive and realistic training environments, mistake tolerance and training in hazardous scenario without causing harm to trainee, cost effective training method, opportunity of training review and training time flexibility (Powell, 2011; Wang & Song, 2011; ADSO, 2005; Coutermash, McDonald & Shoop, 2011). These advantages make simulator widely used in aviation training, driver training, medical training and rehabilitation. This paper will discuss the simulator usage and simulator sickness as experienced by a few organizations in Malaysia. This information was captured during MIROS Simulator’s Team visit to these organizations in understanding the simulator operation.

Simulator sickness

Beside electrical and other physical hazards poses by simulator, there is a health hazard induced by simulator, namely simulator sickness. Simulator sickness is a type of cyber sickness which occurred as a result of exposure to Virtual Environment (VE). A VE is an environment simulated by a computer to imitate real environment or imaginary environment and be displayed on a computer screen or special equipment like driving and flight simulator. Kolasinski (1995) reported that simulator sickness was initially documented by Havron and Butler in 1957 in helicopter training. Researchers came out with few theories in identifying the causes of simulator sickness and the most widely accepted theory is sensory conflict theory. This theory suggests that the human body is unable to handle the conflict between movements captured by the human eye and the nonmovement of the human body which is being picked by the human body vestibular system (Nichols & Patel, 2002; Kennedy & Frank, 1985). Simulator sickness look a lot like motion sickness but it normally affects smaller proportion of exposed population and usually much less severe. However, Kennedy and Fowlkes (1992) as cited in Nichols and Patel (2002) states that the after effects of simulator sickness can persevere for several hours and it may present a safety risk to the subject. The main difference between simulator sickness and motion sickness is simulator sickness can be induced by visual simulation alone. There are complex signs and symptoms associated with simulator sickness which make it being described
as polysymptomatic. This is because the symptoms exhibited are varied among people. Most common symptoms reported by simulator user are general discomfort, fatigue, sweating, salivation, headache, nausea, disorientation and stomach awareness. Predicting simulator sickness is not an easy task since the sickness is contributed by many factors (polygenic); technologically and individually. Some of technology contributing factors are projection quality, viewing condition: field of view, flicker and lag Nichols and Patel (2002) and position tracking error. For individual factor, gender, age, illness, adaptation and position in simulator has been identified as contributing factor to simulator sickness (La Viola Jr., 2000; Kennedy & Frank, 1985).

Consequences of simulator sickness

Crowley (1987) as cited in Kolasinski (1995) identified four important consequences of simulator sickness which are (1) decrease simulator use, (2) compromised training, (3) ground safety and (4) flight safety. Flight safety is included since Crowley work is based on simulator sickness in army aviation. Even the consequences are noted from aviation field, most of his ideas were supported by other researchers as they were applicable to other type of simulator. Simulator sickness has been a notable obstacle in training and research using simulator (Cobb, Nichols, Ramsey, & Wilson, 1999). Nichols and Patel (2002) review shows that early exits due to high symptom levels ranged from 4% to 16% and 10% of simulator users report that they are experiencing simulator sickness. 9% of participants from Lee, Cameron and Lee (2003) study also reported mild degree of dizziness after simulator driving session. Early exit recorded by these researchers is an evidence of decrease in simulator usage as sickness experienced discourages them from continuing operating the simulator (La Viola Jr., 2000). Training may be compromised when the trainees are experiencing simulator sickness (La Viola Jr, 2000). Firstly, sickness could distract the trainee during the session which make them less attentive and effecting their performance. This condition has been supported by Cobb et al (1999) and Brooks et al (2010) when they found a negative correlation between simulator sickness symptoms and participant performance. Secondly, trainee might adopt behaviours to avoid the symptoms in simulator which could be injurious if transferred into real life task. For example, trainee might close the eye to avoid the symptom (headache) during the training in driving simulator. This action is forgivable as it is safe in simulator but it could lead to road crash if the trainee close the eye during real life driving activity when he experiencing headache. Postural instability and flashback induced by simulator exposure associate simulator sickness with fall risk (Kolasinski, 1995) and ground safety. This condition is evidenced by a case of a pilot whose vision suddenly inverted 180 degrees while he was driving home hours after exposure to VE: attending flight simulator training (La Viola Jr., 2000).

Simulator usage in Malaysia

In Malaysia, at least four organizations were identified using simulator for their training purposes. Simulators used were flight simulator, driving simulator, ship simulator and cargo handling simulator. These simulators are categorized as virtual interactive simulation since operator or trainee’s input is crucial in determining the direction of simulation while the human element is not modeled (ADSO, 2005). From the discussion, all of these organizations acquire simulator as their training tools mainly because of cost effectiveness, training benefit and safety issue. For costing, simulator usages reduce the cost of machine’s fuel, less or no dependencies on the real machine which make the real machine available for operation and reduce the cost of real machine maintenance due to training’s incidents. In term of safety and training benefit, these organizations agreed that simulator enable them to train the trainee in controlled and safe environment even when they are conducting training on hazardous environment. For example, pilot can be train on how to operate the flight when they are having engine failure and crane operator can be train to manage their crane during storm. This condition also give the courage to the trainee that they are able to face the unexpected event without harming themselves. Other benefits of training effectiveness offered by these simulators are the structured and computerized module where every trainee is undergoing the same training, opportunity in training repetition and replay to ensure the trainee really master the skill and knowledge, improvement in trainee’s psychomotor skill, cognitive and perception about task, recordable and evaluable training performance and effective scheduling. Effective scheduling was reported as very important for flight and cargo organization as simulator allows them to have training around the clock regardless of weather or external condition.
In aviation industry, simulators are mainly used as a training tool for pilot to perform their conversion training and to renew their flying license. A flying license for every pilot is only valid for 6 months and they need to undergo test on simulator to renew it before they are allowed to fly again. Department of Civil Aviation (DCA) is the responsible agency in granting the certificate of use for each simulator before it can be used as pilot’s qualifier. This certificate is only valid for 1 year after the DCA auditor conduct the plot or objective and subjective testing on the simulator.

By purpose of training and licensing, flight simulator can be regarded as a critical machine in this organization. By having these simulators, pilots can be trained on how to fly a new model flight even when new model flight is yet to be available in the organization. Therefore, once the new model aircraft received, the team is already prepared to expand their operation and increase their profit. Since the cost of flight simulator is high which is around USD 17 million excluding spares, the organization established a program that give public an opportunity to experience piloting the aircraft via flight simulator with some amount of fee. Therefore, besides of internal and external training purpose, flight simulator also being used as an entertainment tool.

Currently, driving simulators have been used for training and licensing purposes in one of the government agency: military department. These simulators training are mandatory for each personnel to obtain their military driving license beside of requirement to drive actual vehicle. Trainees also required to drive a variety of vehicle, ranging from passenger cars, 4-wheel drive SUVs and lorries. Driving condition also be designed in such way that mimic their future working environment like driving on paved road, off road / unpaved road, combat situation and noncombat situation.
This organization also acquires both types of simulators for training and licensing, which is fixed and motion based simulator. Fixed based simulators are imitative cars and lorries while motion based simulators are derived from 4-wheel drive vehicle. Simulator usage in training and licensing gave this organization a huge cost reduction especially in fuel and maintenance cost. Training session also works in motivating the trainees as some of them have no experience in driving prior the training and enable them to be trained in safe condition as simulators are forgivable tools. Trainees also reported that they are gaining a lot of benefit from training especially in maneuverings vehicle that they never exposed to and maneuvering in harsh condition. This condition is aligned with Coutermash, McDonald and Shoop’ (2011) study where maneuverer practicing in simulator has been marked as important by trainee in making things better (Coutermash, McDonald, & Shoop, 2011).

**iii) Ship simulator**

Ship simulator which is built in a huge room to imitate the large ship condition was used to train the new cabin crews on operating the ship and approaching the port. The training module includes the ship operation during the normal climate and harsh climate like storm, heavy rain and normal rain.
Beside of training in handling their own ship, the trainee also be trained on interacting with other ship which could be simulated by the trainer in operation room or simulation linkage with another ship from another simulator room. By having linkage facilities, the trainer could monitor the training progress of two cabin crews simultaneously.

iv) Cargo handling simulator

Cargo handling simulators were built and introduced by organization to train the port’s machinery operator in operating the Ship to Shore Crane and Rubber Tyred Gantry Crane. Simulator in this organization is very practical and user friendly as it allows the plug and play function. Panel in this simulator is switchable to serve the training purpose; either the Ship to Shore Crane or Rubber Tyred Gantry Crane training.
This function is crucial in assuring effective training transfer as trainees are exposed into a real cockpit condition (situated learning). Therefore, they could familiarize themselves with panels and switches and ease them in operating real machine. Trainees are exposed into safety hazard if the simulator is differing from real machine (ADSO, 2005). The panel switching capability also reduces the simulator cost in term of procurement, maintenance and manpower. Furthermore, the usability characteristic poses by the simulator make the switching task simple and can be done by trainer within 30 minutes. Both types of simulators are used in early stage of training to avoid accident as the cost of accident is too huge where a crane will cost around RM 2.5 million. Simulator usage also solved the training time constraint as most of the time, cranes are full equipped for operation and maintenance. Beside of new comer training, crane simulators were also being used for refresher course. This refresher course is meant to improve former operator’s skill which would increase the productivity and for level improvement from lower machine operator into a higher level operator.

**Simulator sickness in Malaysia**

Currently, the severity of simulator sickness in Malaysia is unknown due to no record have been made available. This is because; most of organizations visited are unaware of this sickness. However, after some briefing on sickness, the driving simulator and cargo handling simulator organization admit that they had experience the sickness and did receive complaints from employee experiencing nausea and dizziness after training. They are also agreed that the sickness will get better on the second simulator experience (adaptation effect). For flight simulator and ship simulator organization, the sickness was considered as negligible. This condition could be supported that the users were not susceptible to motion sickness. However, the flight simulator organization is aware that simulator sickness risk is higher for the public who wish to experience the aircraft flying in their simulator. Therefore, they come out with some guideline to be met by participant before the simulator exposure like free from heart, back or neck problem, not prone to motion sickness, not an expectant mother and free from drug or alcohol influence. Even without sickness
awareness, some organization took some initiative to make the training session better. For driving simulator organization, they reported that the trainee are required to do some exercise before the simulator training while cargo handling simulator organization allow the adaptation and frequent break during the training. All of organizations encourage the trainee to stop the training if they fell unwell.

Suggestion for improvement

Since Malaysian doesn’t have a solid data on criticality of sickness in Malaysia, therefore it is highly suggested that we adopt the current practice use by simulator users in other countries as an added value on organizations current unwritten practice. For example, La Viola Jr. (2000) reported that many air forces bases implement a mandatory policy where a pilot is prohibited from flying an aircraft within 12 – 24 hours after flight simulator exposure. ADSO (2005) also report that Advance Flight Simulator (AFS) team patrolling the disorientation caused by simulator sickness by disallowing the crew from driving motor vehicle within 2 hours of simulator training. In entertainment industry, many VR entertainments centre require the user to not to drive for at least 30 – 45 minutes after exposure to reduce the road crash risk (La Viola Jr., 2000). Organizations are also advised to document the feedback and sickness symptoms showed by the simulator users after the simulation exposure. This documentation is believed to be very meaningful to support the sickness identification before MIROS’ work on sickness measurement completed. Feedback recorded can be compiled with the absenteeism and incidents occurrence after the training to find the simulators after effects in Malaysia environment. Currently, MIROS is working on the simulator sickness measurement validation. Once the validation process completed, the measurement process is expected to be one of step in simulator usage procedure. This measurement has a twofold function which is firstly concern about users and secondly is about the simulator performance (Kennedy, Lane, & Lilienthal, 1993). By identifying the degree of simulator sickness severity, the operator is able to provide immediate user’s awareness on the effect and take necessary precautions to reduce risk in subsequent activities. Reports on symptoms may be indicative of a simulator malfunction, and can be used for troubleshooting purposes. It also can be used to assess the impact of technology modification and training syllabus changes. In driving training industry, there is a plan of using simulator as training tool in driving institute. This plan believed to benefit the new driver in term of exposure of varieties of driving condition like raining, congestion and night time driving which hardly be done in current training module. However, in simulator sickness point of view, this plan can’t be executed for time being due to risk of sickness and unavailability of simulator usage procedure. Furthermore, managing and monitoring the sickness will be a huge challenge since it would involve variety of people and they are scattered after training.

Conclusion

Simulator is a great training tool as it offers interactive and realistic training environments, mistake tolerance, enable the training in hazardous scenario without causing harm to trainee; cost effectiveness, opportunity of training review and training time flexibility. However, a special attention need to be given on simulator sickness as it is a complex syndrome and could counter the benefit offered by simulator. A proper documentation, simulator usage and simulator sickness management procedure are believed be able to mitigate the sickness and result in more effective training.

Reference


Simulator Sickness: A Threat to Simulator Training


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