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Dust, Noise and Chemical Solvents Exposure of Workers in the Wooden Furniture Industry in South East Asia

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Abstract: A study was carried out to evaluate the dust, noise and chemical solvents exposure among workers in the wooden furniture industry in the South East Asian region comprising Malaysia, Thailand, Indonesia and Vietnam. A total of 30 factories were selected from each country for the study. Air quality samples at the machining and sanding workstations were measured using the micro-orifice uniform deposit impactor (MOUDI), which separated the particles into different sizes. The results showed that the average dust concentration in the machining section was lower than that in the sanding section, but total inhalable dust particles of less than 10 μm in diameter, was less than 25% by weight. Portable noise-level measurements showed that the rough-milling operations recorded the highest noise-level in the furniture factories in the region. Personal dosimeter measurement results show that 43% of the workers were exposed to noise-levels higher than the permissible limit, with 34.7% of the workers suffered from hearing handicap. The study also found that the current exposure levels for both chemical solvents and formaldehyde in the wooden furniture industry in the countries within the South East Asian region were higher than the Permissible Exposure Levels (PEL). Therefore, it was apparent that despite the existent of a comparable Occupational Health and Safety regulations in the region, its implementation and enforcement within the wooden furniture industry must be improved to ensure the workers safety and health.

Key words: Safety and health, workers, wooden furniture, permissible exposure limit

INTRODUCTION

Dust, noise and chemical solvents are serious safety and health concern among workers in wooden furniture manufacturing, as it strongly influences workforce productivity (Whitehead, 1982; Fairfax, 1995, 1996; Hursthouse *et al*., 2004; Holcroft and Punnett, 2009). The high dust concentration and the high noise-level emancipating from the use of many different types of machines in the production process, together the use of lacquers and paints, often the acid-curing type, with high amounts of organic solvents (>50%), which is released to the environment during the finish curing process, have strong effects on the workers health and safety in the wooden furniture manufacturing factories (Eleftheriou, 2002; Thorud *et al*., 2005). Despite the safety and health concerns arising from the dust, noise and chemical solvents in wooden furniture manufacturing industry, reports on the subject matter is limited (Anonymous, 2008). In fact, workers safety and health is assumed to be a cost factor, rather than a productivity improvement factor, which in turn contributed to the low labour productivity among wooden furniture manufacturers in the region (Anonymous, 2008; Ratnasingam *et al*., 2009, 2010). Therefore, such studies is required to provide the necessary information to both mill managers, policy makers as well as the general public, to ensure greater attention is given to the workers safety and health concerns.

Wood dust is one of the most common organic dusts workers' are exposed to in the furniture manufacturing industry. Studies have found that exposure to wood dust can cause health effects from nasal mucosa damage, irritation and sino-nasal cancer, while deep lung deposition leads to lung cancer and impaired respiratory function (Mikkelsen *et al*., 2002). Wood machining

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processes, such as shaping, routing and sanding produce particularly high levels of dust emission. Nevertheless, the wood dust exposure levels is influenced by the airflow field in the working area, worker inhalation rate and ventilation system, while the level of its toxicity varies with the characteristics of the wood dust, such as the wood specie and size of dust particles (Mikkelsen *et al*., 2002). Although, there is are existing dust emission control regulations within the countries in the South East Asian region, the stipulated standard of 5 mg m^{-3} is often exceeded due to improper dust extraction system and poor machining conditions (FMR, 1989; Ratnasingam and Scholz, 2008). Nevertheless, reports on the subject are sparse and hence, efforts to control dust emission in the wooden furniture manufacturing industry in the region is hampered (Ratnasingam and Scholz, 2008).

On the other hand, noise sources in the furniture manufacturing factories include: (1) structural vibration of machine frames, (2) aerodynamic turbulence of the rotating tools and (3) dust and wood chips extraction system (Ratnasingam and Scholz, 2008). Although, regulations to control noise exposure are existent among all countries in the South East Asian region, its effectiveness to protect the workers hearing remains debatable (Ratnasingam and Scholz, 2008). For instance, the Factories and Machinery (Noise Exposure) Regulation of 1989 of Malaysia, stipulates that the maximum permitted noise exposure limit for workers in the woodworking industry should not exceed 90 dBA for a 8 h period, its effectiveness to provide adequate hearing protection to the workers remain debatable (Ratnasingam and Scholz, 2007; Anonymous, 2008). In woodworking environments where noise reduction measures implemented are often insufficient due to the variable processing parameters, the use of hearing protection among workers are highly recommended. Further, the woodworking industry is also known to be relatively low in investments into low-noise processing technologies and tools, as hearing protection is often deemed as sufficient to safeguard the workers hearing (Fairfax, 1995). Nevertheless, the reliability of the noise exposure limit as stipulated in national regulations and the use of hearing protection, as adequate protection for workers hearing remain debatable, as reports on noise exposure of workers in the woodworking industry, particularly wooden furniture manufacturing is relatively sparse (Ratnasingam and Scholz, 2008).

Further, chemical solvents exposure of workers is often from the coating processes, using different types of lacquers such as nitrocellulose, acid curing, polyurethane and ultra-violet coatings to finish the wooden furniture. In South East Asian region, however, acid-curing lacquers have a predominant lead over other types of coating materials, accounting for almost 75% of the market share (Anonynous, 2008). The acid-curing lacquers are based on alkyd and amino resins with a high amount of organic solvents. The amino resins are urea-formaldehyde or melamine-formaldehyde resins and the curing is initiated by an acid, usually p-toluene sulphonic acid, which eventually releases some amount of the organic solvents and free formaldehyde to the environment. Hence, during surface coating with acid-curing lacquers, the workers in the furniture factories can potentially be exposed contemporarily to both organic solvents and formaldehyde. Despite the availability of chemical exposure control regulations in the countries within the South East Asian region, its effectiveness to control exposure is highly contentious (Ratnasingam and Scholz, 2008). Although, the Occupational Health and Safety (Use and Standard of Exposure of Chemicals Hazardous to Health (USECHH)) Regulations 2000 in Malaysia, stipulates the use and standard exposure of chemicals hazardous to health, its effectiveness within the wooden furniture industry in Malaysia remains unknown (Anonymous, 2008). Further, with continuous improvements in coating materials which is likely to affect both exposure pattern and exposure levels, it is important to establish the current industrial exposure levels for chemical solvents from the acid-curing lacquers used.

Therefore, a study was conducted to determine the dust, noise and chemicals exposure levels among workers in the South East Asian wooden furniture manufacturing industry, including countries such as Malaysia, Thailand, Indonesia and Vietnam and evaluate the extent of hearing damage among the workers in the industry. The findings would possibly help identify measures that could mitigate noise and chemicals exposures faced by workers in the regional wooden furniture industry.

MATERIALS AND METHODS

The study was carried out in 30 large-sized wooden furniture-manufacturing factories (i.e., larges factories are defined as those employing more than 100 workers, with an annual sales turnover in excess of US$ 10 million) in each of the study countries, i.e., Malaysia, Thailand, Indonesia and Vietnam. The factories were selected on the basis of their reportedly good health and safety records as suggested by the respective national furniture trade association and also their voluntary consent to participate in the study. As a result of the large scope of work, the study was carried out over a period of 9 months between March to November 2009, with assistance of the respective national furniture trade association of Malaysia, Thailand, Indonesia and Vietnam, which provided the necessary logistic support. The study was carried out in seven distinct parts.

In the first part, the air-borne dust concentration and particle size distribution of dust was evaluated at the 30 large furniture factories in each of the country. Sampling periods of 8 h were undertaken at the machining station and sanding stations in each of the factories, to determine the time-weighted average value of wood dust concentration. The conditions at the work stations in the factories were reflective of the current industrial practices. Air quality samples at the two work stations were measured using the micro-orifice uniform deposit impactor (MOUDI), which had a ten-stage rotating impactor with filters, to separate the particles into different sizes. By operating the instrument at selected flow rate and pressure drop across the stages, particle sizes of 18, 15, 12, 10, 8, 5, 3.2, 1.8, 1 and 0.56 μm were measured. By weighing the impaction stage before and after sampling, the particle size distribution of the air-borne dust was constructed as described (Marple *et al*., 1991).

The second part of the study involved the evaluation of noise-level and noise-profile in the sample factories. Noise-level measurements were made using a calibrated portable sound level meter (UEI model DSM-101), as reported by Fairfax (1996). The measurements were made by walking through the factories, while continuously measuring the noise level using the portable sound level meter, which was then analysed using the UEI acoustics software to depict the peak noise levels and noise profile throughout the factory, as described by Kokkola and Sorainen (2000).

The third part of the study involved the measurement of noise-level exposure of 1500 workers from the different machining sections, from the 30 furniture factories, using calibrated personal dosimeters, complying with BS6504, which used the 90 dBA/8 h dose as the reference with a 3 dBA exchange rate. The measurements provided an overall noise-level exposure experienced by these workers during their 8 h working shift.

The fourth part of the study quantified the possible noise-induced hearing problems among the workers, using audiometric tests of the 1500 workers carried out by two licensed audiologists, with the aid of audio-chambers and medical equipments capable of testing in the range of 500-8000 Hz in 500 Hz intervals. The measurements made provided an overall assessment of hearing problems due to noise among the workers in the wooden furniture manufacturing factories.

The fifth part of the study involved air sampling at the surface coating departments of the 30 wooden furniture factories. All the factories were applying the coating materials by spray equipment, which was also the most widely used method in the industry (Anonymous, 2008). The air sampling was carried out over three subsequent days in the surface coating departments of the factories on a total of 200 workers in each of the participating countries, in the surface coating departments (including sprayers, handlers and general workers), with a total of 500 parallel samples of solvents and formaldehyde collected over average sampling time of 30 min. The solvents were sampled using charcoal sampling tubers (SKC 226-01) supplied by Dorset, UK, while formaldehyde was sampled using silica-sampling cartridges supplied by Millipore Corp., USA. The sampling tubes were placed at the collar of the workers close to the breathing zone, to ensure representative sampling of exposure levels. After sampling, the tubes were stored at -20°C until desorption and analysis. Industrial exposure to organic solvents most often consists of exposure to a complex mixture of solvent vapours. When two or more solvents with similar toxicological effects are present, the combined exposure rather than the individual exposures is determined, which is often referred to as additive effect (Thorud *et al*., 2005). The concentration of the additive effect of the various solvents and formaldehyde in the sampling cartridges were determined by external standard calibration using the 3 M Organic Vapour Monitors and the GMD 570 formaldehyde Diffusive Sampler, respectively, as described in the study by Thorud *et al.* (2005) and Anonymous (2008). The data were then handled by using the statistical package SPSS version 11.0 on a personal computer, to extract and present the results accordingly. The sixth part of the study involved the compilation and analysis of occupational accident data from the respective national furniture trade organization and the respective national Occupational Safety and Health Departments for the years 2004 - 2008, to establish the average national occupational accident rate for the participating countries. In this context, the quality of the reporting by the respective national organizations is assumed similar, although some verification were undertaken to ensure its reliability as suggested by Ratnasingam and Scholz (2008).

The seventh part of the study aimed to establish the reasons causing industrial accidents and identifying the necessary control and mitigating factors that could be recommended to minimize the rate of occupational accidents in the wooden furniture manufacturing industry in the South East Asian region. This part of the study involved an interview with a group of randomly selected fifteen production workers from each of the factory in the respondent countries, who were asked to select the primary reasons for occupational accidents from a list of

25 pre-determined factors. Such qualitative interview was deemed appropriate to identify the causes of occupational accidents as suggested by Arezes and Miguel (2008).

RESULTS

The results of this study are presented in seven parts.

Part I: Dust exposure of workers in the wooden furniture industry: The average dust concentration and dust particle size distribution in the two work stations are presented in Table 1. The average air-borne dust concentration at the machining work station (64.5 mg m^{-3}) was lower than that recorded in the sanding work station (88.2 mg m^{-3}). The values recorded in this study were higher than the standard 8 h TWA MEL for wood dust of 5 mg m^{-3} (FMR, 1989; HSE, 1999) and therefore the high air-borne wood dust concentration in the wooden furniture factories poses respiratory-related health hazards, as reported previously by Ratnasingam *et al.* (2009).

In terms of particle size distribution, this study revealed that less than 25% of the air-borne dust by weight, at the two work stations, were less than 10 μm. Hence, the results indicate that only a small portion of the air-borne wood dust particles is capable of penetrating into the lower parts of the respiratory system to cause serious health problems. However, the dust particles from the machining processes were coarser than the particles from the sanding process, due to the different cutting process (Ratnasingam and Scholz, 2008). The results from this study also affirm the fact that the wood sanding process resulted in two distinct particle size distributions due to the abrading and ripping actions on the material, as suggested previously by Chung *et al.* (2000). This study indicates that the wood dust characteristics from wood machining processes differ and it's the air-borne wood dust concentration and not its particle size distribution, that poses serious threats to the respiratory system of workers in the wooden furniture manufacturing factories. In this context, improving the exhaust and ventilation system at the workplace and the use of dust protection gadgets by the workers, are highly recommended to minimize the air-borne wood dust exposure levels.

Table 1: Dust emission characteristics in the wooden furniture industry

Country	Average dust concentration in machining area (mg m^{-3})	Average dust concentration in sanding area (mg m^{-3})	% of Air-borne dust (by weight) of less than 10 μm in diameter	Current industrial standard for dust emission
Malaysia	52	86	26	<5 mg m^{-3}
Thailand	71	95	25	<5 mg m^{-3}
Indonesia	74	93	27	<5 mg m^{-3}
Vietnam	61	79	23	<5 mg m^{-3}

Note: Based on a sample of 120 factories

Part II: Average noise levels in the wooden furniture industry: The average noise-levels recorded in the South East Asian wooden furniture manufacturing industry is shown in Table 2. It is apparent that the highest noise-level of 130 dBA was recorded in the rough milling sections of the furniture factories, while in the machining section, only the high-speed router recorded noise-levels higher than the permissible 90 dBA. The rough milling section, involving heavy-duty wood machining operations such as the moulding, ripping and planning are regarded as machines emitting high levels of noise (Ratnasingam and Scholz, 2007). The relatively large stock removal using large capacity drive motors explain the high levels of noise experienced in the rough milling section of the wooden furniture factories. On the other hand, the noise levels in the machining section were lower due to lower stock removals during the machining operations and also the use of drive motors of smaller capacities (Ratnasingam and Scholz, 2008).

Part III: Noise level exposure of workers: The personal dosimeter results, expressed as percentage of 90 dBA/8 h dose, are shown in Table 3. The results show that 43% of the workers involved in the study were exposed to higher dose than the permissible one, while the balance 57%

Table 2: Noise-levels in wooden furniture manufacturing

Section	% of workers	% of workers using hearing protection	Average noise-level (dBA)	Machine	Average noise-level (dBA)
Rough mill	43% (2580 workers)	WP-27 HPDW-73	130	Moulder Surface-Planer Thicknesser	150 125 115
Machine shop	57% (3420 workers)	WP-5 HPDW-3 DHP-92	67	Shaper Narrow Band-Saw Router Mortiser Tenoner Multi-Borer	85 55 110 50 60 40

Note: Figures represent average values of the 120 factories surveyed in the four South East Asian countries. Abbreviations-WP: Wear protection, HPDW: Have protection, but do not wear, DHP: Don't have protection

Table 3: Noise Induced Permanent Threshold Shift (NIPTS) among workers

% of workers	Noise Induced Permanent Threshold Shift (NIPTS) in 4-6 kHz band (dB)	Years at work	Hearing impairment
8.9	>40	>10	Significant
25.8	30-40	3-10	Slight
65.3	<30	<3	Not Significant

Note: Figures based on the workers sample population of 2000 were exposed to a less dose, which is quite similar to the reports by Fairfax (1996) and Kokkola and Sorainen (2000). The workers in the rough milling sections of the wooden furniture factories exposed to the higher noise levels than the permissible one, compared to their counterparts in the machining sections, clearly reflects the need for the provision of hearing protection to these workers.

Part IV: Noise induced hearing problems among workers: The results of the audiometric tests from this study are expressed as Noise-Induced Permanent Threshold Shift (NIPTS). It is apparent that 25.8% of the workers in this study have a slight handicap with permanent threshold shift between 30 and 40 dB, while 8.9% of the workers have significant handicap with permanent threshold shift greater than 40 dB. The percentage of workers having no hearing handicap is 65.3% (Table 3). These results imply that the noise levels in the wooden furniture factories can significantly impair workers' hearing and hence, the use of hearing protection and job-rotation among the workers must be strictly implemented, in order to ensure a hearing conservation program within the industry.

Part V: Chemical solvents and formaldehyde exposures: A summation of the chemical solvents and formaldehyde measurements is presented in Table 4. Since, the solvent exposure occurred as complex mixtures of several solvents, the solvents exposures were calculated as additive effects, as described by Thorud *et al*. (2005). The average of all chemical solvents measurements was 1.43 ppm, while formaldehyde measurements averaged 1.93 ppm. The predominant chemical solvents detected in the vapours were ethanol and ethyl acetate (Table 4), although, the proportions of the various chemical solvents will vary according to the formulation of the coating material (Thorud *et al*., 2005). The average measurements for all solvents and formaldehyde found in this study exceeded the occupational exposure limit, as stipulated in the existing regulations in the participating countries for chemical exposure. Although, during the surface coating operations the workers used personal face mask, it proved to be insufficient to prevent exposure to the high levels of solvents and formaldehyde, as the breakthrough of the chemical solvents increased to 56% after 3 h of use, suggesting the need for the use of high quality air-purifying masks with charcoal filters (Anonymous, 2008). The limited numbers of spot measurements at both inside and outside the masks suggest that the suitability of such masks in minimizing chemical solvents exposure is highly in doubt, as it has a reasonably high breakthrough rate after several hours in use.

Table 4: Chemical exposure in the wooden furniture industry

	Average exposure (ppm)	Range (ppm)	Permissible Exposure Limit (PEL) as stipulated in standard (ppm)	Primary solvents
Chemical solvents	1.43	1.03-1.89	0.55	Ethanol, ethyl acetate, aliphatics C_4-C_8, acetone, 1-propanol, methyl ethyl ketone
Formaldehyde	1.93	1.66-2.18	0.30	

Note: Figures based on a sample of 2000 air samples

Part VI: Average national occupational accidents rate: On the basis of the published data from the respective national Occupational Safety and Health (OSH) organizations, it is apparent that occupational accidents in the wooden furniture manufacturing industry in the South East Asian region is relatively high, compared to their counterparts in Europe. Nevertheless, the rate of occupational accident reflects the following pattern: Vietnam>Indonesia>Thailand>Malaysia, where Vietnam has an average of 75 reported accidents per 1000 workers per annum, while Malaysia has an average of 23 reported accidents per 1000 workers per annum (Table 5). In terms of productive time loss, a similar pattern is also observed as Vietnam reported 145 h lost per 1000 man-hours of production time per annum, while Malaysia recorded 28 h lost per 1000 man-hours of production time per annum.

Part VII: Occupational accident inducing factors: Table 6 provides a summary of the factors that lead to

Table 5: Average rate of accidents in the wooden furniture industry

Country	No. of Accidents reported per 1000 workers per annum	Hours lost per 1000 man-hours of production time per annum	Average calculated loss in production capacity (%) due to accidents (due to accident)
Malaysia	23	28	5.3
Thailand	31	44	7.5
Indonesia	39	58	8.1
Vietnam	75	145	12.3

Note: Based on data from National OSH database and Trade Organizations (2004-2008)

Table 6: Occupational accident inducing factors

Factors	Frequency of citation by respondents (%)	Ranking of importance
Lack of formal safety and health system	63	6
Lack of precautions to avoid accidents	89	1
Workers attitude	75	5
Unskilled workers	76	4
Lack of management commitment towards health and safety	80	2
Poor enforcement of safety and health regulations by authorities	79	3

occupational accidents in the wooden furniture manufacturing industry in the South East Asian region. Although, the rate of occupations accidents vary between the countries covered in the study, the causal factors show a high degree of similarity. Among the factors cited is the lack of safety and health system, lack of precautions to avoid accidents, unskilled workers and lack of management commitment towards workers safety and health and poor enforcement of safety and health regulations. In this context, the workers in the wooden furniture industry in the South East Asian region have lower safety and health standards compared to their counterparts in Europe and Scandinavia (Arezes and Miguel, 2008), due to the prevalence of low-wage economy within the wooden furniture manufacturing industry in the South East Asian region, which strives on the use of unskilled, migrant workers to ensure low production cost (Rampal and Nizam, 2006).

DISCUSSION

Although, this study is based on a limited number of wooden furniture factories, it is tailored to be representative to assess dust, noise and chemical solvents exposures in the wooden furniture industry in the South East Asian region, which is predominated by the large manufacturers. According to Ratnasingam and Scholz (2008), the largest 50 manufacturers account for almost 65% of the total wooden furniture production in these countries, suggesting the reliable representation provided by these factories on the national scale. Thus, this study provides a useful evaluation of dust, noise and chemical solvents exposures in the South East Asian wooden furniture industry, which has never been previously reported (Anonymous, 2008).

The results of the study provides evidence to support the fact that dust emission in the industry is much higher than the permissible limit set out in the respective national standards. Nevertheless, despite the high dust concentration, the total amount of inhalable dust of less than 10 μm in diameter (measured in weight) is less than 25% minimizing the amount of inhalable dust the workers are exposed to in their work environment. This is most likely due to the fact that most of the wood resources, such as Rubberwood (*Hevea brasiliensis*), Meranti (*Shorea* sp.) and Nyatoh (*Pallaquim* sp.), used in wooden furniture manufacturing in the South East Asian region have medium to coarse texture, which produces particulates of relatively larger sizes (Lehmann and Frohlich, 1988; Martin and Zalk, 1997; Bemer *et al*., 2000; Vinzents *et al*., 2001; Schlünssen *et al*., 2008; Wutjaree *et al*., 2009).

On the other hand, the study revealed that the noise-levels in the wooden furniture manufacturing industry, especially in the rough-milling operations, are generally higher than the permissible limit. The machines with high cutting rates, such as the moulder, surface planer and ripsaw, in this section explains the high noise-levels recorded (Ratnasingam and Scholz, 2008). The high stock removal rates (often in excess of 1.0 mm) using drive motors of large capacities to produce high cutter-block revolutions result in high noise levels. Further, the labour intensive operations in the rough milling section, explains the high percentage of the workers in the wooden furniture factories exposed to high noise-levels. Inevitably, these workers would experience a hearing handicap, as shown by the shift in the noise-induced permanent threshold (NIPTS). The study also demonstrates that very little attention is currently given to protecting the hearing of the workers surveyed, as only 33% of the workers who need hearing protection habitually, wear hearing protection gadgets.

In terms of chemical solvents and formaldehyde exposure the results of the study reveals that the current exposure levels exceeds the occupational exposure limits stipulated in the national standards, suggesting that there is a need to enforce stricter the standards to ensure lower exposure levels (Anonymous, 2008). Further, the personal face masks provided to the workers is insufficient to protect them from chemical solvents and formaldehyde exposure, which may seriously affect their health and safety. In this context, masks with charcoal filter or masks with supplies of pressurised air is highly recommended for workers in the surface coating departments to minimize the exposure to chemical solvents and formaldehyde (Thorud *et al*., 2005).

Compared to their counterparts in Europe and Scandinavian countries, the study reveals that workers in the South East Asian wooden furniture industry are exposed to higher dust, noise and chemical solvents levels than the permissible standards (Vinzents and Laursen, 1993; Lazarus, 2003; Fernandez *et al*., 2009) and without stricter enforcement of the existing Occupational Safety and Health regulations in the region, this trend that compromises the workers safety and health is expected to continue. Further, the higher chemical solvents exposure in the South East Asian wooden furniture industry as reflected in this study can also be attributed to the use of different grade of coating materials, which is emits higher Volatile Organic Compounds (VOC), while being of lower cost. The low cost phenomenon prevalent in the South East Asian wooden furniture industry also explains the slow adoption of environmental friendly manufacturing practices, which encourages the use of coating materials with lower VOC's.

In terms of average occupational accidents rate, it is apparent that the South East Asian wooden furniture industry has a higher accident rate compared to their counterparts in Europe and Scandinavia (Fernandez *et al*., 2009). This higher accidents rate is probably attributed to the unstable workforce, predominated by migrant foreign workers, who lack the necessary knowledge and skills to avoid workplace accidents (Ratnasingam and Scholz, 2008). Further, the lack of management commitment towards safety and health and the relaxed enforcement of safety and health regulations do not encourage higher safety and health standards in the wooden furniture industry. Inevitably, the low-wage characteristic of the South East Asian wooden furniture industry serves as a deterrent for a stable workforce, which in turn denies the workers of the necessary knowledge and skill for safe and health work habits (Ratnasingam and Scholz, 2008).

Industrial implications: This study shows that the present occupational safety and health standards, with regards to dust, noise and chemical solvents, are breached in the wooden furniture manufacturing industry in the South East Asian region. Further, the implementation and enforcement of these regulations within the industry has been relatively weak and hence, the overall status of the workers' health and safety is compromised within the industry (Rampal and Nizam, 2006). The low-cost economy so prevalent within the South East Asian wooden furniture industry also implies that workers welfare is often overlooked, while the focus is primarily on cost competitiveness (Ratnasingam and Scholz, 2008). This is attested by the high proportion of migrant foreign workers in the South East Asian wooden furniture industry, who by nature of their contractual employment are prepared to compromise on their safety and health, in return for higher earnings (Rampal and Nizam, 2006). Although, workers' health and safety has a strong bearing on overall labour productivity, the results from this study shows that efficient and environmental friendly manufacturing practices is not widely practiced within the South East Asian wooden furniture industry. Investments into efficient dust extraction, noise reduction and chemical exposure abatement systems are relatively small in the South East Asian wooden furniture industry, when compared to their counterparts in Europe and Scandinavian countries (Rampal and Nizam, 2006). As a result the precautionary steps taken to ensure compliance with workers safety and health regulations are weak in many countries throughout the region. The study also revealed that due to the lack of management commitment, some of the basic premises for workers safety and health are ignored, on the notion that it incurs cost. In this context, the South East Asian wooden furniture industry is well below standard in terms of workers safety and health, when compared to their counterparts in Europe and Scandinavia (Anonymous, 2008; Black and Dilwoth, 2007; Arezes and Miguel, 2008; Welling *et al*., 2009).

In essence, effective and efficient law enforcement is vital in ensuring the compliance to the existing Occupational Safety and Health (OSH) law in the region. Nevertheless, all stakeholders also need to share this responsibility, as the workers safety and health will significantly affect the labour productivity, which in turn governs the overall business profitability. Nevertheless, to re-examine the reliability of the existing standards on dust, noise and chemical solvents exposures in the South East Asian wooden furniture industry to minimize workers safety and health concerns, a more comprehensive and in-depth study of the industry may be necessary to draw safe conclusions.

CONCLUSIONS

This study on the dust, noise and chemical solvents exposure in the South East Asian wooden furniture industry reveals that the workers are exposed to levels higher than the Permissible Exposure Level (PEL). The high dust, noise and chemical solvents exposure suggest that protective gadgets must be provided to all workers and its' wearing must be made compulsory to minimize exposure. Further, the existing Occupational Safety and Health regulations must be implemented and enforced strictly to ensure compliance within the wooden furniture manufacturing industry, which it turn will boost labour productivity, thereby enhancing competitiveness.

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