OCCUPATIONAL EXPOSURE TO WOOD DUST

by

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The investigations undertaken and described in this thesis were carried out during 1995-1998 in the National Occupational Health and Safety Commission (NOHSC), and the Department of Public Health and Community Medicine, the University of Sydney, under the supervision of Dr. John Mandryk. Unless otherwise stated or except where due acknowledgement has been made, the materials embodied in this thesis are the result of my own original work and have not been submitted fully or in part to any other university or institution for the award of any other degree or diploma.

The following five papers have been submitted for publication, from the results of field and experimental investigations described in this thesis:


In addition, a report has been prepared for the Timber Industry:


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DEDICATION

This thesis is dedicated to woodworkers
in Australia.

ABBREVIATIONS
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>ACGIH</td>
<td>American Conference of Governmental Industrial Hygienists</td>
</tr>
<tr>
<td>AM</td>
<td>arithmetic mean</td>
</tr>
<tr>
<td>EAA</td>
<td>extrinsic allergic alveolitis</td>
</tr>
<tr>
<td>ELISA</td>
<td>enzyme-linked-immunosorbent assay</td>
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<tr>
<td>FEF&lt;sub&gt;25%-75%&lt;/sub&gt;</td>
<td>forced expiratory flow during the middle half of the FVC</td>
</tr>
<tr>
<td>FEV&lt;sub&gt;1&lt;/sub&gt;</td>
<td>forced expiratory volume in one second</td>
</tr>
<tr>
<td>FVC</td>
<td>forced vital capacity</td>
</tr>
<tr>
<td>GM</td>
<td>geometric mean</td>
</tr>
<tr>
<td>GSD</td>
<td>geometric standard deviation</td>
</tr>
<tr>
<td>HSE</td>
<td>Health and Safety Executive</td>
</tr>
<tr>
<td>IgE</td>
<td>immunoglobulin E</td>
</tr>
<tr>
<td>IgG</td>
<td>immunoglobulin G</td>
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<tr>
<td>IOM</td>
<td>Institute of Occupational Medicine</td>
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<tr>
<td>IPM</td>
<td>inhalable particulate mass sampling</td>
</tr>
<tr>
<td>ISO</td>
<td>International Standard Organization</td>
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<tr>
<td>LAL</td>
<td>limulus amebocyte lysate</td>
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<tr>
<td>LPS</td>
<td>lipopolysaccharide</td>
</tr>
<tr>
<td>MMAD</td>
<td>mass median aerodynamic diameter</td>
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<tr>
<td>MMF</td>
<td>maximum mid flow rate</td>
</tr>
<tr>
<td>MMI</td>
<td>mucous membrane irritation</td>
</tr>
<tr>
<td>NIOSH</td>
<td>National Institute of Occupational Safety and Health</td>
</tr>
<tr>
<td>NSW</td>
<td>New South Wales</td>
</tr>
<tr>
<td>ODTS</td>
<td>organic dust toxic syndrome</td>
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<td>OR</td>
<td>odds ratio</td>
</tr>
<tr>
<td>OSHA</td>
<td>Occupational Safety and Health Administration</td>
</tr>
<tr>
<td>PEF</td>
<td>peak expiratory flow</td>
</tr>
<tr>
<td>RAST</td>
<td>radioallergosorbent test</td>
</tr>
<tr>
<td>RPM</td>
<td>respirable particulate mass sampling</td>
</tr>
<tr>
<td>SD</td>
<td>standard deviation</td>
</tr>
</tbody>
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ABSTRACT

Occupational exposure to wood dust and biohazards associated with wood dust (endotoxins, (1->3)-\(\beta\)-D-glucans, Gram (-)ve bacteria and fungi), their correlation to respiratory function, and symptoms among woodworkers have been investigated in the present study.

Wood dust, endotoxins, and allergenic fungi are the main hazards found in woodworking environments. Relatively very few studies have been done on wood dust exposure. The present study was designed to comprehensively investigate the health effects of wood dust exposure, and in particular provide new information regarding:

- Exposure to (1->3)-\(\beta\)-D-glucans in an occupational environment;
• Levels of exposure to wood dust and biohazards associated with wood dust in different woodworking environments;

• Correlations among personal exposures, especially correlations between (1->3)-β-D-glucans and fungi exposures, and endotoxins and Gram (-)ve bacteria exposures;

• Effects of personal exposure to biohazards on lung function;

• Effects of personal exposure to biohazards on work-related symptoms; and

• Determinants of inhalable exposures (provide which factors in the environment influence the personal inhalable exposures).

Workers at four different woodworking processes; two logging sites, four sawmills, one major woodchipping operation and five joineries situated in the state of New South Wales in Australia were studied for personal exposure to inhalable dust (n=182) and respirable dust (n=81), fungi (n=120), Gram (-)ve bacteria (n=120), inhalable endotoxin (n=160), respirable endotoxin (n=79), inhalable (1->3)-β-D-glucan (n=105), and respirable (1->3)-β-D-glucan (n=62). The workers (n=168) were also tested for lung function. A questionnaire study (n=195) was carried out to determine the prevalence of work-related symptoms.

The geometric mean inhalable exposure at logging sites was 0.56 mg/m$^3$ (n=7), sawmills 1.59 mg/m$^3$ (n=93), the woodchipping mill 1.86 mg/m$^3$ (n=9) and joineries 3.68 mg/m$^3$ (n=66). Overall, sixty two percent of the exposures exceeded the current standards. Among joineries, 95% of the hardwood exposures and 35% of the softwood exposures were above the relevant standards. Compared with green mills, the percentage of samples, which exceeded the hardwood standard was high for dry mills (70% in dry mills, 50% in green mills).

The respirable dust exposures were high at the joineries compared with the other worksites. Exposure levels to fungi at logging sites and sawmills were in the range $10^1$-$10^4$ cfu/m$^3$, woodchipping $10^3$-$10^5$ cfu/m$^3$ and joineries $10^2$-$10^5$ cfu/m$^3$. The predominant fungi found at sawmills were *Penicillium* spp. High exposure levels of *Aureobasidium pullulans* were also found at two sawmills. At the woodchipping mill the predominant species were *Aspergillus fumigatus*,...
Penicillium spp., and Paecilomyces spp. The sawmills, which employed kiln drying processes, had lower exposure levels of fungi compared with the green mills. Those workplaces which had efficient dust control systems showed less exposure to fungi and bacteria. Although mean endotoxin levels were lower than the suggested threshold value of 20 ng/m$^3$, some personal exposures at sawmills and joineries exceeded the threshold limit value. The mean inhalable (1->3)-β-D-glucan level at the woodchipping mill was 2.32 ng/m$^3$, at sawmills 1.37 ng/m$^3$, at logging sites 2.02 ng/m$^3$, and at joineries 0.43 ng/m$^3$. For the respirable size fraction, mean endotoxin and mean (1->3)-β-D-glucan concentrations were much lower, being similar to observed dust concentrations. Significant correlations were found between mean inhalable endotoxin and Gram (-)ve bacteria levels (p<0.0001), and mean airborne inhalable (1->3)-β-D-glucan and fungi levels (p=0.0003). The correlations between mean respirable endotoxin levels vs Gram (-)ve bacteria exposure levels (p=0.005), and respirable (1->3)-β-D-glucan exposure levels vs total fungi levels (p=0.005) were also significant.

Significant correlations were found between lung function and personal exposures. Multivariate analyses showed that the effect of all the personal exposures on cross-shift decrements in lung function was more prominent among sawmill and chip mill workers compared with joinery workers.

Woodworkers had markedly high prevalence of cough, phlegm, chronic bronchitis, frequent headaches, throat and eye irritations, and nasal symptoms compared with controls. Among the woodworkers, smokers had a high prevalence of chronic bronchitis (20%) compared with non-smokers (10%). Some workers also reported a variety of allergy problems due to exposure to various types of wood dust.

Both joinery workers and sawmill and chip mill workers revealed significant correlations between work-related symptoms and personal exposures. Chronic bronchitis was significantly correlated with personal exposure to wood dust, endotoxin, (1->3)-β-D-glucan, fungi, and Gram (-)ve bacteria among joinery workers. Whereas among sawmill workers chronic bronchitis was
significantly correlated with personal exposure to endotoxin, (1->3)-\(\beta\)-D-glucan, and fungi. Woodworkers showed significant positive correlations between percentage cross-shift change (decrease) in lung function and respiratory symptoms. Significant inverse correlations were also found among percentage predicted lung function and respiratory symptoms.

The elevated inhalable dust exposures observed in this study can be explained by a combination of factors, including: lack of awareness of potential health effects of wood dust exposure among both management and workers, aging equipment, inadequate and ineffective dust extraction systems or usually none especially for hand held tools, poor maintenance of the ventilation system in some, non-segregation of dusty processes, dry sweeping, and the use of compressed air jets.

The determinant-of-exposure analysis confirmed the field observations. The significant determinants of personal inhalable dust exposures (n=163) were found to be: local exhaust ventilation, job title, use of hand-held tools, cleaning method used, use of compressed air, and green or dry wood processed. Type of wood processed was not found to be statistically significant.

A majority of workers (~90%) did not wear appropriate respirators approved for wood dust, while the workers who did wear them, used them on average less than 50% of the time. Workers should be protected by controlling dust at its source. When exposure to wood dust cannot be avoided, engineering controls should be supplemented with the use of appropriate personal protective equipment.