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Injury Prevention in Timber Processing: A brief review of the literature for the New Zealand timber processing industry.

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Summary

There is little published literature examining sawmilling injury prevention (IP) and the modest material available does generally not evaluate the implementation of interventions. There is even less material that is specific to New Zealand and recent; although the reports and publications by COHFE contribute to progress in addressing musculoskeletal disorders in the New Zealand timber processing industry. The keys types of interventions that are described in the literature cover workspace design and geometry; organisational factors and workflow; reduction of forces and handling loads; positive safety climate or culture.

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1. About the industry

New Zealand produces approximately 22 million m^3 of plantation timber each year, and the forestry industry contributes around 3% of gross domestic product (GDP), directly employing around 21,000 people (2006 figures; MAF, 2007). Indirect employment created by forestry and wood processing is estimated to account for a further 100,000 jobs (Forestry Insights, 2007).

Around 75% of the total harvest is further processed in New Zealand into sawn timber, pulp and paper, panel products, furniture components and dozens of other products before being either consumed domestically or exported. Timber processing in New Zealand includes pulp and paper (four companies), panelboard (eight), around 400 sawmillers and 80 remanufacturers.

There are around 14,000 employees in activities associated with the use of wood (statistics New Zealand, 2000) and the production of rough sawn timber from all forests has increased from just over 2 million m^3 in 1990 to nearly 4.5 million m^3 for the year ended March 2003. This quantity of sawn timber was produced by 365 sawmills – many small and owned by farmers. Over half produced less than 500 cubic metres of sawn timber each in the March 2003 year (MAF, 2007).

2. Objectives

This review is intended to provide a brief overview of the background material - rather than being a comprehensive literature review. It was funded by ACC as part of a larger project aimed at determining:

- what has been done to prevent injuries, and in what sectors;
- what, if any, links exist between injury type from the data and injury research;
- what interventions, methods, approaches, etc can or cannot be applied to the New Zealand timber processing industry;
- where the gaps in knowledge regarding sawmilling IP are.

3. Method

The review material was drawn from a search of Ergonomics Abstracts (database) and also literature banks from previous timber processing research.
Criteria used to determine inclusion of literature in this review were:

1. Content directly relevant to injuries in the timber processing industry; including sawmilling, remanufacturing, pulp and paper production and other operations (plywood, veneer etc).
2. Peer reviewed material (journal papers, book chapters, refereed conference papers, and reports from major Research Centres) along with trade magazine articles, newspaper items, high level tertiary student studies or personal communications on the same topics.
3. Material was generally restricted to publications since 1995, although some pertinent references are included, irrespective of date.
4. Material relating to injuries as opposed to injury prevention is included in the review – as there is limited material available on injury prevention methods.

4. Results

The review is presented in two sections: one outlining the presence and nature of injuries in timber processing, as described in the literature, and the other describing published injury prevention methods and interventions.

4.1 Injuries in the Timber Processing Industry

4.1.1 New Zealand and Australia

The forest industry and associated processing operations includes a wide variety of potentially hazardous operations. In New Zealand, according to ACC claims data, soft tissue injuries account for around 50% of all new claims in log sawmilling and wood product manufacturing (ACC, 2000), followed by lacerations/puncture wounds (14%), deafness (10%), fractures (7%) and gradual process disorders (7%). These same data indicate ‘work property or characteristics’ (details unspecified) were the most likely causes. The back or spine was the most commonly reported injured body area, followed by finger/thumb, hand/wrist, ear and shoulder (ACC data, October, 2001). In Australia, incidence of injuries and disease in sawmilling activities is twice the national average (National Occupational Health and Safety Commission NOHSC, 1994, as cited by Driscoll *et al*, 1995).

Tappin *et al* (2003) analysed accident records of 37 New Zealand mills to establish which tasks were problematic with respect to musculoskeletal disorders in the industry. Timber handling activities associated with tables, filleting and sawyers were highlighted as needing further study with the back and low back the main body areas affected (37% of the reported injuries).

Driscoll *et al* (1995) concede that incident/injury rates in Australian sawmilling are high, with some consistent elements contributing to sawmill incidents: for example ‘large piles of logs’ was identified as a major hazard for fatalities, during loading/unloading.

Although published outside the determined range, Larsson, Mahoney and Steele (1993), provided some specific insight into injuries among sawmill workers in New Zealand. The paper describes an approach (funded by ACC) whereby injury data (from the compensation system) was screened to identify occupations and tasks with high incidence of severe and permanently disabling injuries. Five years of injury data were analysed. 43% referred to hearing loss. Sprains and strains, amputations and superficial injuries comprised the next largest injury types: excluding hearing losses, 53% of injuries were to upper limbs (19% lower limbs, 15% back).

4.1.2 Other countries

The timber processing industries around the world conduct similar activities, and record similarly high numbers of injuries.

A Canadian study reviewed compensation claims of 3779 sawmill workers, and found musculoskeletal injuries accounted for 335 total cost and 38% of total lost time, and 47% of the claims studied, with the upper limb most frequently involved (45%)(Jones and Kumar, 2004). Their subsequent investigation of physical demands highlighted the importance of considering the effect of multiple variable definitions in ergonomics risk assessment (Jones and Kumar, 2007). Christensen *et al* (1995) confirmed high prevalence of musculoskeletal symptoms in the wood and furniture industry following observations and interviews among 281 employees. However, as with many other studies in this area, dose-responses at an individual level were not established.

A further common shortcoming in the literature is the absence of intervention design and implementation detail in studies. In Canada, the incidence and causes of repetitive strain injuries were assessed in ten wood products companies and around 1400 workers completed questionnaires: a high percentage reported awkward body and arm postures and highly repetitive motions (Murphy and Ritmiller, 1995). The workers in plywood/veneer mills were more likely to report work-related injury than workers in planing mills or sawmills. The authors suggest that the injuries were likely to be related to ergonomics mismatches, and that they would benefit from ‘ergonomic intervention’; details of suggested changes and how to bring these about, are not provided however. ‘Ergonomics issues’ are also described by Scherzinger (1992) as being related to up to 33% of sawmill injuries,

Ergonomics issues are also described by Scherzinger (1992) as being related to up to 33% of sawmill injuries. in studies that draw such conclusions, it would be helpful to know at least whether the ergonomics solutions concerned would be simple to implement, or whether significant barriers exist – such as pay rate complications blocking job rotation.

Outside the USA and Canada, the bulk of the Northern Hemisphere literature is from Northern Europe.

A cross-sectional study in France (Heran-Le Roy *et al*, 1999) found high occurrences of intensive manual materials handling in wood and paper products and manufacturing, but did not report on associated injuries.

In addition to MSD factors, other occupational hygiene issues have been identified. Noise exposure is of concern in sawmills internationally, with the nature of the work contributing to noise hazards. An Alberta study (Koehncke *et al*, 2003) monitored noise levels in nine sawmills, finding them all above the 85 dB Occupational Health Level. There is evidence that health issues are associated with wood and timber processing – for example with an increased risk of asthma symptoms among sawmill workers; exposure to green pine sawdust is possibly a risk factor for atopy (Douwes et at, 2006).

4.2 Injury prevention in the Timber Processing Industry

There has historically been little peer-reviewed material about injury prevention and its effectiveness for the timber processing industry in international journals. However, some information about injury prevention principles has been published in popular press articles and industry literature, and recent work funded by the ACC and Department of Labour in New Zealand is generating more objective and practical material.

4.2.1 New Zealand and Australia

The most extensive information available specific to New Zealand is that produced by the Department of Labour & ACC (2005) and COHFE (Tappin *et al*, 2003a; Tappin *et al*, 2003b; Tappin *et al*, 2004). The Department of Labour document offers guidelines (including data from the COHFE Reports) to assist in hazard identification in the Timber Processing Industry and provide ideas of injury prevention measures. Primary hazard topics include Safe Access, Manual Handling, Lockout and Machine Guarding. Tappin *et al* (2003a) provided intervention ideas for addressing musculoskeletal disorders in sawmills which included:

- Workflow management: such as matching workflow to workforce numbers; rotation of staff; altering table speed to provide more constant timber flows
- Reducing breakout force from tables by using: roller chains, low friction edges/surfaces, and tilting the table
- Optimising workspace layout and geometry: such as setting appropriate timber heights for the workforce; having boards overlap the table edge to increase accessibility; using packet risers
- Good trolley design: sufficiently large landing pad for first boards; easy to move trolleys; good surface on which to move them
- Task technique training to cover range of scenarios and
- Techniques suitable for task requirements.

Similarly, Tappin *et al* (2003b) provided MSD intervention suggestions for filleting, including physical design (work area layout, jockey and cradle design, glove design), organisational design (workload management, sustainable workpace, packet sizes) and training design (task technique training).

In Australia, Worksafe Victoria produced material to address manual handling hazards in the sawmill industry (Worksafe, 2005). The Manual handling Solutions document describes the main tasks attributable to MH injuries, and a range of acceptable risk control solutions.

Some potential interventions for New Zealand processing plants were identified by Van Wyk (2000) during the compilations of a checklist to help OSH inspectors determine hazards (looking at conditions that can cause injury, death and lost time). Five interviews were conducted with open ended questions; three from timber processing plants, one OSH inspector and one H&S education provider. Suggested controls included:

- Identifying injuries and accidents in first few weeks of employment or when not doing routine work – the risk being minimised by training, close supervision and constant monitoring
- Having procedures and safety equipment to eliminate strapping accidents (visor, gloves, chainsaw chaps)
- Addressing accident prevention from top down – ie gaining management commitment first
- Upgrading maintenance systems to incorporate full planning and hazard identification.
- More specific controls were suggested within the hazard checklist, for various injury types. These included: design ideas (designated walkways, guard rails, improved walking surfaces), protective equipment (gloves, eye protections, safety harnesses), inspection and operational procedures.

Primary accident mechanisms in data analysed by Larsson, Mahoney and Steele (1993) included loss of balance; lifting/stretching/strain; slipping and tripping. The researchers produced hazard shortlists after conducting local risk assessments at three New Zealand mills. From these, third year industrial design students suggested possible design solutions including: alternative log handling/storage methods, using a counterbalanced handler rather than manual hook and strop method; crane mounted hydraulic grab, to reduce double handling. Manual handling of timber could be reduced using automated timber bin sorters and stackers: the bins are transportation units and can take the timber electronically on rails to the various other operations (sapstain dip, yard etc). Two noise reduction design concepts were also presented and it was noted that structural noise abatement was at that time virtually non-existent.

In a study peripheral to this review, but with some relevance, Langley and Marshall investigated kinematic and kinetic factors relating to lumbar spine forces in manual handling tasks in a sawmill (Langley and Marshall, 1988). They determined that vertical wrist/load velocities were associated with high forces, as were increasing rates of truck displacement and greater upper limb reaching. They considered only technique (as opposed to other interventions) and concluded that a freestyle handling technique (as opposed to traditional prescriptive 'straight back' approach) was appropriate. They also advocated workers being as close to the load as possible and slowing the lift down.

More recently, Driscoll et al (1995) considered traumatic fatalities in forestry and sawmills in Australia. They did not specifically review interventions as part of the study but did recommend that correct work practice, resulting from appropriate training, has prime importance and also well maintained and properly guarded equipment. A NZ Forest Industries article promotes the use of the scissor lift (NZ Forest Industries, December 2001) and another press article (Clark, 1999) – reported key safety factors in sawmills and logging sites as being communication, discipline, leadership and accountability (by a guest speaker at a PeopleSafe workshop). Another speaker emphasised the need for a safety culture starting at the top with the forest company.

A Forest Industries magazine article (McLean, 1997) highlights the need for 'buy in' by employees to the process of safety, with checklists and inspections leading to OSHs Achiever Status. Training material provides information relevant to injury prevention, although its validity and effectiveness is unknown. A sawmill safety manual describes hazards and procedures to avoid injury for each operation area. These range from use of protective equipment, techniques and methods, and use of lock out systems (Waiariki Institute of Technology, 1999). Health and safety training specific to wood processing is included in the National Qualifications Framework (Fitec).

Evaluation of effectiveness

Tappin *et al* (2004) evaluated interventions over a period of time, which had been presented to two mills: some elements that showed indications of success included:

- reduction in forces through better table surfaces and reduced board contact;
- workspace geometry improvements to reduce reaching and double handling;
- workflow improvements through better communication and availability of trained staff;
- preventative maintenance programmes.

4.2.2 Other countries

In Sweden, Nolimo and Eklund (1996) reviewed ten small wood processing companies and showed that the driving forces for change projects were decreased costs and increased productivity.

The Timber Industry Ergonomics group in Sweden studied fifteen sawmills in the early 1970s and produced a booklet outlining measures to improve the work environment (Timber Industry Ergonomics Group, 1977). Although now outdated, there has been little produced since which provides industry with specific injury prevention interventions based on practical research. Focus is on working environments (noise, air pollution, climate, lighting and vibration), body positions, movements and workloads. Practical interventions are described in the form of a fictitious new mill which incorporated the following principles (Village, 1991):

1. Job design allows for postural change and movement, and choice in work posture;
2. Each employee controls his own working speed;
3. Buildings and machines designed so no-one works alone;
4. Decision-making production groups enabled for planning, operation and maintenance;
5. Education to foster job enrichment and job rotation.

Subsequently a Checklist was produced (Almqvist, 1992) which referred to the above information and additional literature, to assist processing plants to address risk factors through design, procedure, personal protective equipment and training.

The introduction of organisation changes in six pulp and paper mills were described by Abrahamsson (1996) in Sweden. The changes influenced various injury risks – for example task rotation to reduce exposure to musculoskeletal risk; integration of maintenance and production work. However, the study explored barriers to effective change rather than examining the results of any organisation interventions.

Scherzinger (1992) identified a number of factors contributing to injury risk in sawmills in Canada, including muscular effort and high forces, repetitive movements, awkward postures and poor lighting influencing speed and posture. Suggested interventions included:

- expanded task rotation
- line speed changes for better board spacing
- alternate work methods to better distribute demands
- adjustable seating and special gloves for better grip.

Suggested improvements to control cabs included

- changes to seat mountings and rails
- relocation of some controls
- task exposure changes to reduce constrained postures.

Provisional reports indicated the implemented changes reduced lost time injuries.

In the Alberta study by Koehncke *et al* (2003) on noise levels the lowest noise level exposures were associated with isolation of the worker in an enclosed cab – however despite working in the cab, many workers were still over the Occupational Exposure Limit (OEL), and usually these were operators that had left the cab on one or more occasions to perform other duties in the mill. Other means of control suggested in this study included various engineering principles, such as enclosing the planer, and constructing tunnels for infeed and outfeed conveyors; insulated barriers between planer and graders; lubrication of saws and other moving parts; muffling of exhaust air cylinders.

In another Canadian study, Lan *et al* (2000) investigated safe tarping systems for wood chip trucks. Bulk loads transported in road vehicle trailers must be retained by a tarpaulin. Tarping systems are used to protect workers against falls from the top of the trailer, whilst climbing on the trailer to attach the tarp. A participatory ergonomics process was used by the researchers to evaluate four systems. Two half-panel systems and a drive system met the evaluation criteria: the recommended systems are operable from the ground, eliminating the risk of falls at source. They also recommend engineering support and user input for any homemade tarping systems.

The Workers' Compensation Board of British Columbia (1999) produced a report on preventing injuries to workers in forest products manufacturing. The report highlights the need for better occupational health and safety programmes, presents detailed information on injuries rates, claims, types and operations and suggests some injury prevention ideas. Accident prevention topics include:

- Overexertion: risk factor identification; design; training
- Falls: Guardrails; floor and roof openings; elevated work platforms; scaffolds and ladder use; personal arrest equipment
- Lockout: securing all parts and attachments to avoid inadvertent use; energy-isolating devices properly locked out
- Safeguarding: physical enclosures to prevent access to a hazardous area; restricted access via safety devices, while hazardous parts are moving; shields, awareness barriers or warning signs; safe procedures, tools and techniques.
- Amputations: fitting adequate safeguards guarding of accessible nip points; use of template, jigs or pushsticks if required when feeding machinery.

Also in Canada, some interventions were described by an occupational health nurse in a veneer/plywood mill (Davidge, 2000). Musculoskeletal disorders were addressed by installing a cross feeder and splicer to reduce twisting and reaching. In addition, staff rotation was introduced, and sit stand stools were introduced to allow variability in workers' positions.

An American case study of two wood processing operators considered upper extremity exposure with a view to informing effective interventions (Bao *et al*, 1999). Surface electromyographhic (EMG) and electrogoniometric measurements quantified muscular and postural loads of the workers during a series of sample work periods. Board positioning and monitoring was the primary task (76% of their time) and repetitive hand exertions or movements seemed to be the majority risk factors, with high forearm force and awkward wrist postures. Improving the unscrambler and board kicking systems was suggested to reduce frequency of using hands to feed the boards, and to reduce the need for re-positioning of boards on the chain. It was also recommended that reducing the load on forearm extensors could reduce forearm disorders and reducing the effort of manually handling each board could be achieved by using a board turning assist device.

The Health and Safety Executive, Great Britain, has published a series of newsletters, Woodnig, through the Woodworking National Interest Group. These have included various interventions aimed at reducing injuries in wood processing. Much of the information reiterates HSE guidelines and legislative requirements, or directs readers elsewhere such as to specific information sheets or reports. However, some of the notable actual interventions mentioned in the newsletters include:

- Recommended procedures for banding timber packs (April 1999). Advantages and disadvantages for various materials are outlined; ensuring a tight secure pack is achieved; periodic inspections to identify broken/damaged bands.
- Addressing manual handling problems by: using vacuum panel lifters; extension tables, conveyors and panel trolleys; carrying aids for large panel and saw blades; rotation among workforce; adequate manual handling training (April 1999).
- Adequate training of operators, assistants and supervisors including safe systems of work, correct adjustment of guards, appreciation of appropriate tooling and suitable working environments; machine specific training and general training, and familiarisation (August 2000 and December 2000).
- Ensuring dust extraction systems are working effectively and maintenance of extraction systems; use and training for respiratory protective equipment (December 2000 and August 2000). Also,
- Avoiding slips, trips and falls by: improving lighting, keeping gangways clear of obstructions, removing waste regularly, using suitable non-slip floor surfaces, addressing trips hazards like uneven flooring, cables, areas with dust and chip build up (December 2002).
- Ladder safety: avoid working from ladders; securely fix ladders so stable during use; not using poorly maintained and/or faulty ladders (August 2002).
- Stacking board materials: store boards flat or in 'pigeon hole' or 'toast rack' racking systems; never stack boards on edge without adequate support (December 2001).

Similarly the HSE produces working sheets with advice on interventions to reduce injuries. Woodworking Sheet number 34 (HSE, 1997) contains information primarily to assist detailed risk assessment with associated general guidance on addressing risk.

Evaluation of effectiveness

An American paper outlines the results of three injury prevention case studies, in the wood products industries (Lile, 1994). Two involved yarders for log movements, but one was a dryer feeder operator, with a worker who had experienced severe back pain. The workspace was redesigned to reduce horizontal handling distance, eliminating back flexion, with a positive outcome for the worker involved who was able to return to full time work. Design aspects were also shown to be significant by Burdorf and Van Duuren (1993) among subjects operating four-sided planning machines. The presence of rising platforms or tables reduced the average working time involved in lifting or carrying of planks by about 10% and also reduced stress on the upper limbs. Roller tracks reduced mechanical loads on the back and the neck.

The importance of safety climate and relationship to safe practice in eight wood processing companies was considered by Varonen and Mattila (2000). They used a questionnaire to measure safety climate and found that the better the safety climate of the company was, the lower the accident rate.

The same authors later examined the effects of addressing work environment and safety activities among eight companies with an above average accident rate and eight companies – i.e. a control group – with below average accident rate. Advice on work environment and safety activities was provided to the ‘experiment’ companies. Safety levels of the work environments were measured with a wide range of checklists based on accident analysis of over 4000 occupational accidents in the wood processing industry (Varonen and Mattila, 2002). Safety activities were studied using further checklists extracted from Diekemper and Spartz (1970) and Uusitolo and Mattila, 1990 (both cited by Varonen and Mattila, 2002). Accident data for the period 1989-1994 were analysed. Improvements following advice and recommendations was significant ($p<0.001$) and safety levels at the end of the study were better than that of the controls. Control and experimental group accident rates both decreased over the experimental time but at a greater rate for the experimental group. The authors concluded that occupational accidents can be prevented by:

- identifying and anticipating hazards
- implementing safety measures concerning the work environment
- initiating safety activities such as provision of safety information and safety rules
- familiarisation of new employees with the workplace
- management and supervisor safety training, allocating active role to the safety committee (Vronen and Mattila, 2002).

Stewart (2001) demonstrated the effects of safety culture in one pulp and paper mill in Ontario. He also used a questionnaire survey based on a model of safety management to highlight to management the deficiencies in management commitment, line ownership of safety and worker attitudes. Other aspects of control were satisfactory, such as safety organisation and equipment.

Recommendations included increasing consistency of enforcement of safety rules; greater worker involvement; worker and staff subgroups to address specific tasks. Acceptance of management of the recommendations resulted in improvements in injury levels and also improvements in commitment as demonstrated by a repeat of the questionnaire survey.

5. Conclusions

The literature contains mostly description of injuries and injury data, or theories on interventions and injury prevention. Very little is reported on actual interventions implemented and evaluations of the effectiveness of these. There have been some recent publications in New Zealand (Tappin *et al* , 2003 and 2004) that have made useful contributions in this direction, but these publications specifically address just musculoskeletal disorders rather than injuries as a whole.

The bulk of the literature describing interventions reports focus on the physical design of specific pieces of equipment in various timber processing operations, and in many cases these studies are applicable to New Zealand industry. This review also includes a range of interventions and recommendations relating to aspects of the system beyond the equipment used; ranging from workflow and organisational changes; training and educational issues; workspace geometry and task design.

Key gaps in the knowledge identified by the review were most notably, a lack of quality evaluative work, and poor identification of the kind and severity of injuries relative to specific task areas. General weaknesses included a lack of genuine systems approach in the study designs; for example, an absence of contextual description that would assist the reader in telling whether or not the findings had relevance in their own country.

It is our impression from conducting this review, that in order to more effectively address the incidence of injury in timber processing, further study is needed to more accurately identify: primary areas of risk, implementable interventions and the outcomes of these.

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This resource is available in hardcopy and on the COHFE website in pdf format.
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