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by Aaltonen MVP

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by Markku VP Aaltonen, LicTech

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Objectives The purpose of the study was to determine the types of occupational injuries that occur in the Finnish furniture industry and to see whether they differ as regards production type and company size.

Methods During a one-year registration period accident events, the actual and potential severity of the injuries, the causes of the accidents, and the measures needed to prevent such accidents were examined in 18 Finnish furniture factories of different types. An analysis of covariance determined the variables affecting the actual and potential severity of the injuries.

Results The 214 accidents registered were lost-time injuries; two of them resulted in slight partial loss of fingertips. The disabling injury rate was 14.4 per 100 workers per year. Wooden furniture production and kitchen cupboard production in large companies had the highest rate. Accidents involving machines comprised half of the material. Saws were the most common machine type. Forty-two percent of the injuries could have been more severe; one injury could have been fatal. The injured persons and their foremen identified the causal factors of the accidents and the needed safety countermeasures well. Sixty-six percent of the causes and 65% of the safety countermeasures were associated with the actions of the workers and the workplace procedures. Nevertheless, only 6% of the identified safety countermeasures were put into force.

Conclusions It was estimated that, in 1987, 2000 on-site accidents leading to at least first-aid at some health care center occurred in the Finnish furniture industry. Special efforts should be taken to improve safety in furniture production in Finland.

Key terms accident investigation, accident research, accident statistics, manufacturing of nonmetal furniture, Nordic cooperation, occupational safety, potential injury.

The manufacture of furniture has been recognized as a hazardous branch of industry (1—5). In North Carolina, the leading furniture manufacturing state in the United States, the most common work-related problems have been noise, dust, machine accidents, chemical vapors, materials handling, and poor housekeeping (1). Especially hazards in the handling of chemicals have been reported (6, 7).

Because of the numerous work environment hazards, safety and health guides and standards have been published in various countries for use by the furniture industry (8—10).

As a part of a Nordic research project (11), Soderqvist & Persson (12) studied occupational accidents in 19 Swedish furniture factories. During the one-year follow-up, 146 injuries were reported, and the disabling injury rate was 6 injuries per 100 workers per year. In the corresponding Nordic study in Norway (13), the disabling injury rate was 6.7 accidents per 100 workers in a year in 20 furniture factories.

Occupational injuries have not been studied much in the Finnish furniture industry. The disabling injury rate of Finnish furniture carpenters was found to be lower than that of house carpenters, but it was nevertheless higher than the average accident rate in the entire industry (3). In another study (14), saws, planes, milling machines, drills, and grinding machines were found to cause most of the injuries in the manufacture of nonmetallic furniture.

The Finnish furniture industry experienced an economic boom in 1987; in the same year 1019 occupational accidents occurred that caused at least 3 d of absenteeism from work. The accident rate (8.4 accidents per 100 workers per year) was slightly higher than that of all industrial branches (15).

On the basis of the present study, it was estimated that, in 1987, 2000 workplace accidents leading to at least first aid at some health care center occurred in the Finnish furniture industry. About a half of these injuries resulted in at least 3 d of incapacity to work and were...
registered in the official accident statistics of Finland. The disabling injury rate of the Finnish furniture industry was double that of the Swedish and Norwegian furniture industry, although the production technology is similar in these countries (11). This difference indicates that the safety culture of the furniture industry is not parallel in the Nordic countries. The accident risk also varies in the furniture industry according to production type and company size. Since minor accidents entail a potential risk for more severe injury, nondisabling injuries (ie, those requiring only first-aid and medical treatment) should be followed also at the company level. This information should be valuable for accident prevention. In order to ensure the competitiveness and the health of the workers in the Finnish furniture industry, efforts should be taken to improve the safety of furniture production to at least the same level as in the other Nordic countries.

The objective of this study was to determine the type of work injuries that occur in the Finnish furniture industry and to determine whether they differ as regards production type and size of company. Another goal was to reveal the factors affecting the severity of injuries and the potential injury risk.

Materials and methods

The occupational injuries were investigated in the participating furniture factories during the course of 12 months (in 1986—1987). All occupational accidents which took place during workhours and which prompted at least first-aid treatment at a medical facility were investigated. Commuting accidents between the home and workplace were not included, nor were injuries which resulted from prolonged strain.

Eighteen furniture firms (table 1) were selected for study on the following bases (16): the company manufactured nonmetallic furniture; the company was a member of the employers' association; the factory was located in the Lahti business region (three were located elsewhere in southern Finland however); the company fell into one of the following size categories: (i) 20—49 workers, (ii) 50—200 workers, or (iii) over 200 workers; the company represented at least one of the following production types: (i) wooden furniture (such as tables, chairs, cabinets), (ii) upholstery (such as sofas, armchairs), or (iii) kitchen cupboards.

The follow-up covered a total of 1482 workers and 71 foremen and involved about 13% of the total Finnish furniture industry. The follow-up of injuries in the large companies was restricted to the department which represented one of the aforementioned production types. Three companies engaged in both wooden furniture and upholstery (combined) production. One company was dissolved due to bankruptcy two months before the end of the follow-up period.

Injury data were collected from the companies' internal accident report forms and their accident information forms to insurance companies. The injured persons and their foremen were also interviewed after the injured persons had returned to work. A special questionnaire form was prepared for the interviews.

The following safety performance indices were calculated: the number of disabling injuries, the disabling injury rate (number of disabling injuries per 100 workers per year), the severity of injuries (total days of sick leave per number of disabling injuries), the average days of sick leave per worker per year due to injuries.

The accident analysis was based on the Finnish accident investigation method (17), which is a variant of multilinear process models in which an accident is seen as a flow of events. The domino theory of Heinrich et al (18) was an early variant which modeled an accident as a one-dimensional sequence of events. The multilinear event-sequencing method models the process resulting in an injury as a sequence of events made up of interactions between various actors of the system (19, 20). The Finnish model considers two actors, the action of the injured person and the action of the source of injury (17).

Altogether 23 variables were investigated for each injury. The variables included data on the injured person, the events preceding the accident sequence, the accident sequence, the injury sequence, and the safety measures needed to prevent such accidents. The categories of variables were selected as suitable for Nordic

### Table 1. Number of furniture factories and of workers involved in the study according to production type and company size.

| Company size | Wooden factories (N) | Upholstery factories (N) | Combined factories (N) | Kitchen factories (N) | Total Workers |
|--------------|----------------------|--------------------------|------------------------|-----------------------|---------------|
| 20—49 workers | 4 128                | 2 63                     | 1 40                   | —                     | 7 231         |
| 50—200 workers| 2 203                | —                        | 1 65                   | 2 216                 | 5 484         |
| > 200 workers | 2 200                | 2 252                    | 1 180                  | 1 135                 | 6 767         |
| Total        | 8 551 (36%)          | 4 315 (21%)              | 3 285 (19%)            | 3 351 (24%)           | 18 1482       |
Table 2. Number of occupational injuries, the disabling injury rate, the severity of injuries, and the number of days of sick leave per worker per year in the furniture factories according to production type and company size.

| Company size | Type of furniture production | Disabling injury rate | Severity of injuries | Number of days of sick leave per worker per year |
|--------------|-----------------------------|-----------------------|---------------------|-----------------------------------------------|
| 20—49 workers | Wooden | 10.2 | 1.3 | 5.7 | 8.9 | 0.6 | 3.7 | 4.3 | 0.3 | — | — | — | 21 | 9.4 | 11 | 1.0 |
| | Upholstery | 11.9 | — | — | — | — | — | 15 | 19 | 0.2 | 33 | 15.3 | 10 | 1.5 | 69 | 14.3 | 11 | 1.6 |
| 50—200 workers | Wooden | 17.2 | 1.7 | 22 | 11.7 | 0.8 | 15 | 26 | 1.0 | 31 | 13 | 5.0 | 69 | 10.0 | 7.5 | 1.1 |
| | Upholstery | 17.2 | — | — | — | — | — | 24 | 17 | 0.2 | 34 | 14.3 | 10 | 1.5 | 69 | 14.3 | 11 | 1.6 |
| > 200 workers | Wooden | 17.2 | 1.7 | 22 | 11.7 | 0.8 | 15 | 26 | 1.0 | 31 | 13 | 5.0 | 69 | 10.0 | 7.5 | 1.1 |
| | Upholstery | 17.2 | — | — | — | — | — | 24 | 17 | 0.2 | 34 | 14.3 | 10 | 1.5 | 69 | 14.3 | 11 | 1.6 |
| Total | Wooden | 18.5 | 1.7 | 33 | 10.5 | 0.7 | 19 | 6.7 | 10 | 0.7 | 64 | 18.2 | 8 | 1.5 | 214 | 14.4 | 8 | 1.2 |
| | Upholstery | 18.5 | 1.7 | 33 | 10.5 | 0.7 | 19 | 6.7 | 10 | 0.7 | 64 | 18.2 | 8 | 1.5 | 214 | 14.4 | 8 | 1.2 |

Results

Safety performance indices

During the one-year follow-up, 214 occupational injuries were registered which led to at least first-aid treatment in some health care center. The injuries were clustered into wooden furniture and kitchen cupboard production (table 2). The disabling injury rate was 14.4 injuries per 100 workers per year. The injury rates differed in regard to production type (P < 0.001) and company size (P < 0.01) (table 3). The highest rates were found in the manufacture of wooden and kitchen furniture of large companies. The disabling injury rate in upholstery work was smaller than the rate in wooden furniture production (P < 0.001). The lowest rate was found in factories with combined production (versus wooden furniture production only P < 0.001). Considering only company size, small companies had the lowest disabling injury rate and large companies had the highest (P = 0.004). The most severe
injuries occurred in the wooden furniture production of small companies, although these companies had a lower disabling injury rate than the rate of all companies. The sick leaves, on the other hand, were shorter in the large companies than in the small or medium-sized ones.

**Accident analysis**

The injured persons most often worked with machines or handled materials. Four main types of accidents were found, covering 91% of all types of accidents (figure 1). The accident types did not differ, however, in regard to production type ($P = 0.534$). Cuts and contusions of a finger and back strain were the most common injuries, comprising 52% of all injuries. Various hand injuries accounted for 61% of all injuries.

Machines were involved in 110 injuries (51% of all injuries). The most common types of involved machines were (N = 110) saws, such as circular, band, multiple edging, dimensional circular, and cross-cutting saws (23%); boring and milling machines (21%); grinders (8%); machine lines and combination machines (6%); planes (6%); gluing and composition machines (6%); others (30%).

Men were injured in 153 cases (71%). The average age of the injured persons was 35 (SD 11.7) years, being 32 years for the men and 41 years for the women. The proportion of young workers among the injured was relatively high; 29% were under 25 years of age. The injuries of young workers were generally not severe, especially those under 20 years of age (average 4 d of sick leave per injury, N = 26).

At least one accident causal factor was identified for 175 injuries (82% of all injuries), and two causal factors were found for 29 injuries (13%). A total of 233 accident causal factors were identified (ie, an average of 1.1 causal factors per injury). Forty-five percent of the causal factors involved unsafe acts of workers, and 21% were related to deficiencies in workplace procedures. One-third of the causal factors involved deficiencies in the technology and work environment. The causal factors differed according to accident types (table 4).

**Actual and potential severity of injuries**

The total of sick leaves for all 214 injuries amounted to 1796 days, including weekends; an average of 8.4 days per injury (standard deviation 12.4). The longest sick leave lasted 92 days. The registered 186 injuries were temporary total disabilities (requiring more than one day’s sick leave), including two cases involving slight partial loss of fingertips. Thirteen percent of the injuries needed medical treatment only (less than one day’s sick leave).

The following variables affected the actual severity of injuries the most (table 5): type of injury (fractures, loss of fingertips, other), injured part of body (shoulders or arms, chest, back), production type (combined pro-

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**Figure 1.** Distribution of the main variables and event chains of the occupational injuries that occurred in the furniture factories (N = number of injuries).
Table 4. Accident causal factors according to accident type in the furniture factories.

| Accident type                                      | N  | %  |
|----------------------------------------------------|----|----|
| Collision with moving machine part or tool          |    |    |
| Improper work method, hazardous work posture        | 11 | 17 |
| Poor machine design or usability                    | 10 | 15 |
| Inadequately guarded machine                        | 8  | 12 |
| Uncontrolled movement, slip                         | 7  | 11 |
| Other                                              | 30 | 45 |
| Total                                              | 66 | 100|
| Hurting oneself on an object                        |    |    |
| Failure to use personal protective device           | 11 | 20 |
| Poor housekeeping                                   | 6  | 10 |
| Poor machine design or usability                    | 5  | 10 |
| Lack of work space                                  | 5  | 10 |
| Other                                              | 27 | 50 |
| Total                                              | 54 | 100|
| Collision with falling, flying or other moving object |    |    |
| Unsafe work planning                                | 8  | 15 |
| Failure to use personal protective device           | 7  | 14 |
| Other causal factors due to work environment        | 6  | 12 |
| Poor housekeeping                                   | 5  | 10 |
| Other                                              | 25 | 49 |
| Total                                              | 51 | 100|
| Strenuous movement                                  |    |    |
| Improper working method, hazardous work posture     | 23 | 54 |
| Lack of work space                                  | 5  | 12 |
| Unsafe work planning                                | 4  | 9 |
| Deficiencies of work environment, scaffolding or passages | 4 | 9 |
| Other                                              | 7  | 16 |
| Total                                              | 43 | 100|
| Other accident types                                |    |    |
| Total                                              | 19 | 100|

Note: Production type includes kitchen cupboards.

Table 5. Variables statistically significant in the analysis of covariance of the actual severity of the occupational injuries that occurred in the furniture factories.

| Variable                          | Injuries (N) | Sick leave |
|-----------------------------------|--------------|------------|
|                                   | Crude mean | Adjusted mean (log-scale) |
| Type of injury                    |             |            |
| Fracture                          | 8           | 46.5       | 1.58     |
| Strain                            | 47          | 9.1        | 0.76     |
| Cut                               | 79          | 5.5        | 0.65     |
| Loss of fingertip                  | 2           | 27.0       | 1.36     |
| Corrosion                         | 73          | 6.1        | 0.71     |
| Burn                              | 3           | 12.3       | 1.65     |
| Acid injury                       | 1           | 7.0        | 1.42     |
| Other                             | 1           | 18.0       | 1.91     |
| Total                             | 54          | 100        |          |

Table 6. Actual severity of the occupational injuries and the risk for the most severe potential injuries in the furniture factories.

| Class | Severity of Most severe potential injuries | Total (N) |
|-------|---------------------------------------------|-----------|
| 1     |                                              | 214       |
| 2     |                                              | 8.4       |

Note: * Test for the hypothesis that all the adjusted category means of the variable are equal.

Safety countermeasures

The need for least one safety countermeasure was identified for 149 injuries (70% of all injuries), two countermeasures for 31 injuries (14%), and three countermeasures for 1 injury. Altogether 214 countermeasures were identified (ie, an average of one countermeasure per injury). Of these, 40% were directed at improving the safety behavior of workers, and 26% at improving workplace procedures. Seventeen percent of all the countermeasures were directed at improving existing technology, and 17% concerned the work environment. The most
important single recommended countermeasures were (N = 214) use of safety gloves (12%), better housekeeping (8%), improvement of machine guarding (8%), improvement of passageways (8%), better planning of work (7%), use of auxiliary equipment or work tools (6%), proper work method or proper use of machine (6%), improved carefulness (5%), enlargement of work space (5%). To our knowledge, only 6% of the identified countermeasures were implemented. However, this figure does not include the possible better use of personnel safety devices.

External validity of the study material
According to official occupational accident statistics, 1019 accidents leading to at least 3 days of incapacity to work occurred in the Finnish furniture industry in 1987 (15). The distributions of the sources of injury in the official statistics and in the study material were statistically equal (P < 0.8).

Discussion
During the registration period, every seventh worker in Finnish furniture factories was inflicted by an onsite injury that led to at least first-aid in some health care center. The injuries in this study were slight. They were cases requiring medical treatment only or temporary total disabilities, including two cases involving slight partial loss of fingertips.

According to the official accident statistics of 1987, the disabling injury rate in the Finnish furniture industry was 8.4 injuries (resulting in at least 3 days of incapacity to work) per 100 workers per year. In this study the corresponding injury rate was slightly less, being 7.2. The occupational injury risk differed significantly according to the production type and size of the furniture companies. Statistical differences according to accident type were not found. The disabling injury rate was highest in large companies and lowest in small ones. This result differs from the findings in other studies, which have reported that small and large companies have a lower injury rate than middle-sized companies (25). In this study it may be possible that not every injury in the small companies, especially minor ones, had been reported to the researchers. In the large companies, the data collection functioned better. The disabling injury rate was twice as high in this study as in similar studies in Swedish or Norwegian furniture factories. The rates were comparable because the studies were conducted with similar methods in these countries (11).

Accidents involving machines comprised half of all the injuries. The most common machine types were saws, drills, and mills. This result has been verified also in earlier studies (14). The injuries occurred mainly during normal production work (i.e., in the use of machines and materials handling).

The factors affecting the actual severity of the injuries differed from those affecting the potential severity of the injuries. The nature of the injury was the most important factor affecting the actual severity, whereas the type of accident mostly affected the potential severity of injuries. Especially falls and moving vehicles seemed to involve a potential risk for severe injuries. All in all, almost every second accident could have led to a more severe injury, and one accident (0.5% of all injuries) led to a critical consequence (i.e., fatality). In a Finnish steel factory, 11% of the investigated injuries could have led to a critical consequence (21). There is a difference in the risk of a potentially severe injury in these two branches of industry. From the viewpoint of accident prevention, the investigation of minor injuries is important because, in other situations, similar accidents might have led to more severe injuries.

The foremen and the injured persons were able to identify the causal factors of the accidents and the needed safety countermeasures for almost every injury. The accidents could not be investigated in more detail because of limited resources. The researchers interviewed only the injured persons and their foremen. This restriction may have influenced the distribution of identified causal factors and countermeasures because only the most distinct and easily recalled factors and measures had been reported. For example, the use of personal protective devices might not necessarily be the best countermea-

Table 7. Variables statistically significant in the analysis of covariance of the potential severity of occupational injuries in the furniture factories.

| Variable                  | Injuries (n) | Potential severity Crude mean | Adjusted mean |
|---------------------------|--------------|--------------------------------|---------------|
| Type of accident          |              |                                |               |
| Fall to lower level       | 6            | 3.00                           | 2.98          |
| Fall to same level        | 7            | 2.43                           | 2.41          |
| Hurting oneself on an object | 52         | 1.94                           | 1.95          |
| Collision with falling, flying or other moving object | 46 | 2.37 | 2.39 |
| Collision with moving machine part or tool | 50 | 2.31 | 2.33 |
| Moving vehicle            | 1            | 3.00                           | 2.61          |
| Strenuous movement        | 38           | 2.18                           | 2.19          |
| Other                     | 5            | 2.20                           | 2.18          |
| Type of production        | P = 0.01860* |                                |               |
| Upholstery                | 33           | 2.21                           | 2.41          |
| Wooden                    | 98           | 2.10                           | 2.27          |
| Kitchen                   | 64           | 2.44                           | 2.59          |
| Combined                  | 19           | 2.26                           | 2.34          |
| All                       | 214          | 2.23                           |               |

* Test for the hypothesis that all adjusted category means of the variable are equal.
sure if the accidents could have been investigated in more detail. However, the personnel in furniture factories had knowledge and competence to identify accident causal factors and to consider proper countermeasures.

The recommended countermeasures were implemented for only 6% of the injuries, although they had been identified for 85% of the injuries. Attention should be directed more to the assumption of safety responsibility, and to the improvement of safety motivation in furniture factories, so that identified safety countermeasures would also be carried out in practice.

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