Work-related injuries and occupational health and safety factors in smaller enterprises—a prospective study

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The aim of this study was to determine whether any of the health, environmental and safety (HES) factors registered by visiting small mechanical enterprises in Norway at the start of the study could predict the risk of occupational injuries in subsequent years. Twelve HES factors, including injury awareness, programme for action, employee participation, training and use of personal safety devices, were registered. A questionnaire was completed by interviewing the employer and observing production. Two variables based on observation of the use of safety equipment were significantly correlated with occupational injuries. There is potential for prevention in smaller enterprises by increasing the use of personal protection devices and safety equipment on machines. Frequent inspection with feedback to the workers is probably the most effective means of attaining the desired result of reducing injuries.

Key words: Health and safety factors; occupational injuries; risk prediction.

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Introduction

The incidence of occupational injuries is high in many sectors of industry and in Norway the number of reported occupational injuries is increasing [1]. This is happening even though several public and private interventions have been implemented to prevent occupational accidents in recent years. Employers and public authorities are thus looking for effective preventive strategies. Several types of industry in Norway have a high incidence of occupational injuries. Metalwork is the occupational group with the highest total cost for work-related compensation claims in Norway [2]. Metal-cutting saws, power presses, drilling machines and lathes ranked among the top five in a study of relative accident frequency per machine unit carried out in a plant manufacturing small precision parts and electrical equipment [3]. The industry category is also known for a high frequency of eye injuries [4]. Also, in other countries mechanical industry has been shown to have a high incidence of occupational injuries. For example, this industry is among the sectors with the highest incidence rates of non-fatal occupational injuries in the USA [5].

A regulation relating to Systematic Health, Environmental and Safety (HES) Activities in Enterprises (Internal Control Regulation) came into force in Norway in 1992. This was a shift from detailed regulations enforced through inspections from public authorities towards making the employer responsible for documenting a safe work environment. All enterprises in Norway must establish a system for internal control (IC) in the area of HES, defined in the regulation as 'Systematic measures designed to ensure that the activities of the enterprise are planned, organized, performed and maintained in conformity with requirements laid down in or pursuant to the health, environmental and safety legislation' [6]. In addition to HES regulations (Table 1), IC also implies other directives, for example on electrical safety and fire protection.

Using a prospective design in a group of mechanical enterprises, we wanted to determine whether any of the HES factors based on the IC regulation or the use of safety equipment could predict the risk of occupational injuries occurring in subsequent years.

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Table 1. Section 5 of the IC regulations with content of systematic HES activities and documentation requirements

Internal control entails that the enterprise shall:	*Documentation*
1 Ensure that those Acts and regulations in the field of health, environmental and safety legislation that apply to the enterprise are accessible, and have an overview of requirements of particular importance for the enterprise	
2 Ensure that the employees have sufficient knowledge of and proficiency in systematic health, environmental and safety activities, including information on changes made	
3 Ensure employee participation so as to utilize overall knowledge and experience	
4 Establish health, environmental and safety objectives	Must be documented in writing
5 Have an overview of the enterprise's organizational set-up, including allocation of responsibilities, duties and authority in regard to the work on health, the environment and safety	Must be documented in writing
6 Identify dangers and problems and against this background assess risks; draw up appurtenant plans and measures to reduce such risks	Must be documented in writing
7 Implement routines to uncover, rectify and prevent breaches of requirements established in or pursuant to the health, environmental and safety legislation	Must be documented in writing
8 Carry out systematic surveillance and reviews of the internal control system to ensure that it functions as intended	Must be documented in writing

Methods

This prospective study was carried out through the Directorate of Labour Inspection and included a random half of all the mechanical enterprises with ≤20 employees in 3 of the 13 labour inspectorate districts in Norway. Table 2 shows the distribution of the number of workers in the enterprises. Some of the enterprises shown in the table have >20 employees because of new employment after they were included in the study. The 307 mechanical enterprises included were visited by an inspector from the local labour inspectorate during spring 1997. The 16 inspectors had received training in the use of a questionnaire (Table 3) on 12 health and safety factors, which was filled out by the inspector by interviewing the employer and observing the production. Questions were answered 'yes' or 'no'; both the scheme and the training of the inspectors included criteria for the answers. In addition, information on the number of workers and type of occupational health service was collected. Injury figures for the years 1997 and 1998 were obtained when the enterprises were revisited in subsequent years. Only lost-day injuries were included and information on the type of injury or injury mechanism was not obtained.

Incidence rates for these 2 years were calculated by dividing the number of injuries by the number of workers and multiplying by 1000.

Logistic regression was used to estimate the relationship between the various HES factors at baseline in 1997 and the subsequent risk of injuries, in which not fulfilling the HES demands was considered as the exposure in the analyses. Injuries were dichotomized into 'no injury' and 'one or more injuries'. The number of employees was included in the analyses since this is correlated with the probability of observing at least one injury in the enterprise and might also be correlated with the HES factors.

Table 2. The distribution of number of workers in the 268 enterprises

	No. of enterprises	
No. of workers	*n*	*%*
<5	88	32.8
5–10	86	32.1
11–15	52	19.4
16–20	28	10.5
21–25	10	3.7
26–30	4	1.5
Total	268	100.0

Results

The analysis included 268 enterprises. Participation in the project was mandatory for the companies because this was a public project and the 39 enterprises (12.7%) not included had either closed down or merged with larger firms. Each enterprise had a mean of 9.3 workers. Among the participating enterprises, 85 (31.7%) workers had experienced one or more injuries during 1997 or 1998 (Table 4), of which 49 (18.3%) had one and 19 (7.1%) had two injuries. The injury incidence rates for 1997 and 1998 were 30.4 and 29.0 injuries per 1000 workers, respectively.

Lack of protective arrangements on machines and equipment showed a significant doubled risk for occupational lost-day injuries and so did lack of use of personal safety devices (Table 5). The typical variables based on the IC regulation were not significantly correlated with occupational injuries. The variable on poor attitude towards the use of the occupational health service was close to significance. The most common type of occupational

Table 3. Questions used by the inspector visiting the enterprises

Occupational health and safety factor	
Risk perception	Does the enterprise have a well-founded risk perception? Attainment of yes to this question requires a grounded specification of the most risky work operation
Injury awareness	What is the most dangerous incident in the enterprise during the last year, and have any preventive measures been implemented? Attainment of yes requires specification of the incident and a preventive measure
Knowledge of security regulations	Does the enterprise have a copy of the most important regulations? Attainment of yes requires a copy of the regulation linked to the most risky work operation specified in question one
Attitude towards the use of health and safety personnel	Does the enterprise have a deliberate policy for the use of health and safety personnel? Attainment of yes requires either implementation as a result of initiative from health and safety personnel or a written programme for action worked out together with them
Programme for action	Does the enterprise have a plan for risk reduction? Attainment of yes requires a written plan with deadlines
Risk-reducing action	Does the enterprise follow up the written plan for action? Attainment of yes requires completion of at least one of the measures in the plan
Employee participation	Does the enterprise have regular meetings to discuss HES with the employees? Attainment of yes requires minutes with written conclusions
Training	Are training needs considered in connection with new employment, new equipment or other changes? Attainment of yes requires an example of training given as a consequence of a change
Special arrangements in times of extra workload	Does the enterprise initiate accident prevention measures in periods of extra workload or activity? Attainment of yes requires an example of such measures
Protective arrangements on machines and equipment	Does all production equipment have the concomitant protective arrangements? A yes requires no lack of such arrangements at inspection round
Use of personal safety devices	Do the employees use the necessary personal safety devices? A yes requires no lack in use of safety devices seen at inspection round
First-aid equipment	Does the enterprise have first-aid equipment? A yes requires that the first-aid equipment be available in the production area and that the content be as prescribed

health service was the multidisciplinary prevention-oriented service (54%), whereas other types, such as treatment-oriented and in-house medical services, constituted only 15% together. As many as 31% of the enterprises had no type of health services.

Discussion

More than one-quarter of the enterprises lacked protective equipment and personal safety devices. This was also found in a study in Finland, where protection against risks was proper in only a quarter of the firms, satisfactory in half and poor or lacking in the rest [7]. There is potential for preventive action by increasing the use of protective equipment, since these factors were associated with occupational injuries in our study. These findings indicate that, in smaller enterprises such as those represented here, injuries are better prevented by following up the workers' use of protective devices than by producing comprehensive administrative IC systems.

Close collaboration with occupational health and safety personnel seems positively to affect injury incidence, which can result both from their expert role and from their ability to notice injury risks when looking at the enterprise from the outside. The multidisciplinary and prevention-oriented occupational health service serving a variety of enterprises in the local area was the most frequent in this study and in general in Norway. The team usually consists of an occupational physician, a nurse, a physiotherapist and an occupational hygienist. Enterprises in this industry in Norway are required by law to subscribe to an occupational health service and the high proportion of enterprises without this service indicates a culture of non-compliance with regulations until compulsion is used. This also comprises potential for preventive action in these companies.

Table 4. The distribution of the number of injuries among the 268 enterprises in 1997 and 1998

	No. of enterprises	
No. of injuries	*n*	*%*
0	183	68.3
1	49	18.3
2	19	7.1
3	6	2.2
4	7	2.6
5	2	0.7
7	1	0.4
9	1	0.4
Total	268	100.0

Table 5. The odds ratios (OR) with 95% confidence intervals (CI) for occurrence of injury among enterprises not fulfilling HES demands (exposed) compared with those fulfilling the demands, adjusted for number of workers, in a cohort of 268 mechanical enterprises

	Total no. of exposed enterprises		*No. of exposed enterprises with injuries*				
Health, safety and environment factor	*n*	*%*	*n*	*%*	*OR*	*95% CI*	*P*
Risk perception lacking	71	26.5	24	33.8	1.22	0.67–2.22	0.52
Injury awareness lacking	185	69.0	51	27.6	0.70	0.39–1.25	0.23
Knowledge of security regulations lacking	101	37.7	33	32.7	1.39	0.79–2.45	0.26
Poor attitude towards the use of health and safety personnel	166	61.9	53	31.9	1.85	0.99–3.44	0.05
Programme for action lacking	178	66.4	51	28.7	0.97	0.54–1.74	0.92
Risk-reducing action lacking	194	72.4	59	30.4	1.26	0.67–2.36	0.47
Employee participation lacking	167	62.3	47	28.1	0.88	0.50–1.55	0.65
Training lacking	92	34.3	33	35.9	1.45	0.83–2.54	0.20
Special arrangements in times of extra workload lacking	138	51.5	41	29.7	1.07	0.62–1.85	0.81
Protective arrangements on machines and equipment lacking	69	25.7	30	43.5	2.14	1.18–3.89	0.01
Use of personal safety devices lacking	75	28.0	33	44.0	2.01	1.13–3.60	0.02
First-aid equipment lacking	25	9.3	7	28.0	1.03	0.40–2.63	0.95

Scientific knowledge about the effect of the IC regulation on occupational injury rates is sparse, although extensive resources have been invested to implement the regulation in industry in Norway. A study among a randomized sample of 2092 private and public enterprises in Norway could not relate a change in accident rates to the implementation of IC [8]. This is in accordance with our results, where fulfilment of the typical IC-related variables was not correlated with a lower incidence of occupational injury. Another study was performed to evaluate the implementation of IC in Norway among 250 large companies with an average of ~500 employees [9]. A higher percentage of self-reported improvement in occupational accidents was found in enterprises with complete IC systems versus those without systems or with incomplete systems. The author remarks, however, that in-depth case studies showed that many of the subjective assessments of improvement were too optimistic. He concluded that IC had not been a failure, but that the goals set for the implementation of the reform and the expected effects in HES conditions had not been achieved. Our study of small enterprises with a mean of 9.3 workers should be cautiously compared with this study of very large enterprises. Ontario has a regulation called the Internal Responsibility System, very similar to the Norwegian IC regulation, and joint health and safety committees are mandatory in the enterprises. A study was performed with data from a survey on the activities of joint health and safety committees in a cohort of enterprises and corresponding data on lost-time accidents were obtained from the Worker's Compensation Board [10]. Regression analysis showed little effect of the committees on lost-time accident rates unless management and labour had some sympathy for the co-management of health and safety. This is also in accordance with our present study, showing minor effects of the IC system.

Several studies have found correlation between HES factors and occupational injury rates. Shannon *et al.* [11] found that lower lost-time accident rates were associated with: concrete demonstration by management of its concern for the workforce; greater involvement of workers in general decision-making; greater willingness of the joint health and safety committee to solve problems internally; and greater experience of the workforce. The activities of the joint health and safety committee and the existence of a written health and safety policy were not related to lower rates. Two older studies comparing plants with high and low accident rates, respectively, showed top management involvement in safety as the main factor associated with low accident rates [12,13]. A study in Canada showed that open communications and positive team spirit in the relationship between the work group and the supervisor were the most important factors in the propensity of work groups to comply with safety rules. Another study in Canada showed that age and attitude towards safety performance were the most powerful predictors of safety performance in the construction industry [14]. But the attitude was not related to exposure to safety training or safety meetings. On construction sites in Finland, a feedback project with a large graph on the wall of the lunch room showing the safety index based on weekly observation rounds resulted in considerable improvement of the safety index [15]. The findings that injury incidence is not mainly influenced by HES

activities as defined by the IC regulation, such as programmes or meetings on the working environment, but rather by feedback on safety behaviour, are in accordance with our results. The above-mentioned studies also underline the importance of the attitude of the enterprises towards safety, in particular from the management. IC might, however, have other effects that are not the subject of this study, such as reduced sick leave and increased HES awareness [8,9].

Limitations to this study included the use of unvalidated questions, only two response categories for the questions and multiple inspectors visiting the enterprises. We tried to compensate for this by specifying criteria for positive answers and by employing thorough collective instruction in the use and interpretation of the questions. The use of inspectors from the local labour inspectorate as interviewers might have tempted the respondents to answer too positively, but the respondents might have feared supplying this authority with incorrect information. Another possible limitation may be under-reporting of occupational injuries, but this is most likely a minor problem since the injury incidence rates in this study match the injury incidence for the production of machines published annually by the Directorate of Labour Inspection. This incidence was 34.7 per 1000 working years in 1998 [1]. No such misclassification can explain the findings. The prospective design used increases the possibility of interpreting the findings as a causal relationship. Nevertheless, caution as a confounder in the relationship between the use of safety equipment and injury incidence cannot be ruled out. This is, however, less likely to be the case since the study objects are enterprises and not individuals.

The association between the use of personal safety devices and a reduced risk of occupational injury could have been a result of implementation of IC or a general positive attitude in the enterprises. However, since none of the HES factors usually associated with IC and which imply the attitude of the enterprises was correlated with the incidence of occupational injuries, this is not likely to be the case. These results found in smaller enterprises cannot automatically be transferred to larger ones, but if using protective equipment is a more effective preventive measure than paper systems and talk in small businesses, it is most likely to be so in larger companies as well.

In conclusion, there is potential for prevention in smaller enterprises by increased use of personal protection devices and safety equipment on machines. Frequent inspection with feedback to the workers is probably the most effective means of attaining the desired result of reducing injuries. Such inspections can be carried out by the enterprises themselves and their occupational health units, but the labour inspectorate should give priority to them as well and not only concentrate on revising the IC systems.

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