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HEALTH HAZARDS AND STRESS FACTORS IN SMALL INDUSTRY – PREVALENCE STUDY IN THE PROVINCE OF UUSIMAA WITH SPECIAL REFERENCE TO THE TYPE OF INDUSTRY AND THE OCCUPATIONAL TITLE AS CLASSIFICATIONS FOR THE DESCRIPTION OF OCCUPATIONAL HEALTH PROBLEMS

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I INTRODUCTION

Work conditions and occupational health problems change along with technical progress. This change is characterized by the introduction of new chemicals into the work environment, by changes in the nature of the physical work load, and by an increase in the mental work load (7, 15, 25, 28, 60, 68).

Little is known about the rapid changes in occupational health problems and the groups of workers primarily affected by these changes. Therefore, methods are needed that enable the development of occupational health problems to be followed.

The information available on the work conditions at small workplaces was scanty, and the organization of occupational health activities was not yet based on legislation in Finland when this study was begun in 1976 (81).

The purpose of this study was to develop and evaluate methods for working out health control priorities for groups of workers. The workers were classified according to type of industry and the occupational titles created for this study. In addition to these classifications, the other essential parts of the methodology were economic survey methods for the assessment of risk factors and indicators for the prevalence of risk factors. However the main problem of this study was the classification of workers into groups for working out priorities in occupational health activities.

In occupational health research, workers have usually been classified according to a specific exposure (38), but types of industry (53, 74, 76, 81), occupational titles (30, 31, 50, 65, 82), phases of production (46, 52), work methods

(1), and occupational status (46, 54) have also been used as criteria for the grouping of workers. These criteria themselves, although widely used, have seldom been the object of investigation.

Workplaces and workers in a given industry often differ with respect to occupational health problems. Therefore, in this study, occupational titles were used as a complementary classification in order to make the health hazards prevailing in a group of workers more homogeneous.

The categorizing of occupations has a long tradition in occupational medicine. Occupational medicine began to develop after occupation-related diseases had been found to exist in important occupational groups. Goldsmiths were the subjects of medical investigation as early as 1472 (64). In the early 18th century Ramazzini presented the knowledge that had accumulated on occupational health by describing the work conditions and the diseases of 54 occupational groups (58).

After the industrial revolution of the 19th century, production became more specialized, and various types of industry were created. The number of different occupations has increased along with technical progress and the division and differentiation of work tasks.

The use of occupational classifications in epidemiologic surveys has been problematic. Anderson (3, 4) found no correlations between rheumatic complaints and heavy jobs in 18 widely ranging occupations. This result was probably due to the internal heterogeneity of his occupational groups. He pointed out the difficulty of studying the effects of work load by occupations, because, in his opinion, occupations tend to be too heterogeneous with regard to work load (3).

The definition of an occupational group and the choice of the occupational groups to be studied are crucial factors. If workers are assigned occupational titles on the basis of too little information about their actual work, they may be as mixed with respect to risk factors as workers classified only according to type of industry. Thus, these occupational titles are not very suitable for epidemiologic studies.

An attempt was made to evaluate an occupational classification following criteria relevant to occupational health. A successful classification could be applied in the awarding of priorities to occupational health problems, and perhaps in epidemiologic surveys as well.

The material for this study was collected in 1976, and it has already been reported as far as the prevalence of different risk factors are concerned (81). The large scope of the study required the collection of data with efficient survey methods, if only for feasibility.

II OBJECTIVE OF THE STUDY

The objective of the study was to survey the prevalence of health hazards and stress factors in small industry and to evaluate methods for the priorization of occupational health activities. More specifically the objective was, on the basis of the prevalences obtained by application of the field method, to evaluate the expediency of the classification according to type of industry and that of the classification according to the occupational titles used in this study for the survey of health hazards and stress factors from the standpoint of changing occupational health problems.

III MATERIAL AND METHODS

SAMPLED POPULATION AND SAMPLE AS A WHOLE

The workplaces and workers were chosen by sampling. The population to be sampled consisted of small industrial workplaces (personnel 5 to 49) in Uusimaa, the southernmost province of Finland. The number of workplaces was 1,430 and the total number of employees was 22,893 (table 1, appendix I[1]).

Small industry was selected because of the scarcity of available information on its occupational health problems (81). Uusimaa was well suited for the study, being the most industrialized part of Finland, where all the major types of industry were represented (81).

The whole sample consisted of 100 firms, with a total personnel of 1,547, of which 1,181 were included in the survey as production workers (table 2, appendix I). Production workers were considered those who worked at least 4 h/d in a production facility (76 %, N = 1,547). The following groups of employees were not included in this study: those whose major task was administrative or service work (18 %, N = 1,547) and those who worked primarily outside the workplace (6 %, N = 1,547).

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[1] The presentation of the material and the ensuing analyses have necessitated the use of a large number of tables. In order to facilitate the reading of the text, some of the tables have been placed in an appendix (appendix I). For the reader's convenience they have retained the numbers they would have had had they appeared in the text.

The results are presented according to the major types of industry in the sample. The sample included 12 workplaces with 145 workers (12 %, N = 1,181) from such small types of industry (table 3, appendix I) that prevalence figures were not calculated separately for each, as they were considered insufficiently representative.

SAMPLING METHOD

The population to be sampled was defined with reference to The Register of Enterprises kept by The Central Statistical Office of Finland. The Register of Enterprises covers the entire private industry sector (12). An advantage over The Industrial Statistics (the alternative source of information) was that it enabled an unambiguous definition of the population according to the size of the workplace (establishment) (appendix II).

In 1975, 100 workplaces were chosen by random sampling to represent small industry. On the basis of the sampling method (9), it was estimated that this sample size would provide an accurate survey of the prevalence of risk factors in the entire small industry of the province of Uusimaa, and also that representative information concerning its major types of industry could be obtained. The pilot study revealed that 1 a would be needed to survey the risk factors in 100 workplaces. One year was also the time limit for the field study. Thus the sample size was also taken to be 100 for reasons of feasibility. The sampling scheme is presented in detail in appendix III.

SUBSAMPLES

From the different types of industry in the sample, the manufacture of metal products, machinery, and equipment and the printing industry were chosen as the subjects of a more-detailed study. They were the largest types of

industry in the sample and were very different from each other as far as production methods were concerned. The workers were classified into occupational health titles (OHTs) within these two types of industry.

In the manufacture of metal products, machinery and equipment (Standard Industrial Classification (SIC) 381-385, 28 workplaces) industries 384 ja 385 were not included in the subsample because there was only one workplace engaged in each of the two types of industry. Correspondingly, in the printing industry one bindery and one silk screen printing shop were not included in the subsample.

Manufacture of metal products, machinery and electrical apparatus (SIC 381-383)

According to The Register of Enterprises, in the manufacture of metal products in the province of Uusimaa, there were 166 workplaces with a total personnel of 2,349 in 1972. Correspondingly, in the manufacture of machinery, there were 144 workplaces with a total personnel of 2,109, and in the manufacture of electrical apparatus 69 workplaces with a total personnel of 1,045 (table 1, appendix I).

The sample consisted of 15 workplaces from the manufacture of metal products (personnel 206), of 6 workplaces from the manufacture of machinery (personnel 109), and of 5 workplaces from the manufacture of electrical apparatus (personnel 65).

In the sampled workplaces 164 employees in the manufacture of metal products (80 % of the personnel) and 76 employees in the manufacture of machinery (70 % of the personnel) were production workers, and in the manufacture of electrical apparatus 52 employees (80 % of the personnel) were production workers (table 3, appendix I).

In the manufacture of metal products the main production methods were cutting, sawing, edging, welding, and surface treatment. In addition metal working such as lathing, milling, and drilling was carried out. Two of the workplaces were specialized in surface treatment.

In the manufacture of machinery metal pressing, lathing, milling, and drilling were more common than in the manufacture of metal products. In two of the workplaces the emphasis was on the development of new products, and the machines were made in small series.

In the manufacture of electrical apparatus, two workplaces produced equipment used in the transmission of electrical energy, two workplaces produced measuring devices for the processing industry, and one workplace repaired and serviced electric motors.

Printing industry

According to The Register of Enterprises the number of workplaces was 249 and the total personnel 3,691 in 1972 in the province of Uusimaa (table 1, appendix I). The sample consisted of 18 workplaces with 276 personnel. Sixteen workplaces using relief or offset presses (industries 342011-13) were accepted to the final sample. The total personnel numbered 226, of which 171 were production workers (table 3, appendix I). Both types of printing presses were used in 11 of the printing shops (N = 16). Four of the printing shops used only offset presses, and one only relief presses. The major products were advertisements and other comparable products.

SURVEY OF OCCUPATIONAL HEALTH HAZARDS AND STRESS FACTORS

Methodology

The surveyed health hazards and stress factors (page 15) were assessed for each worker. This approach was based on the "risk model": "A potential health hazard is always present if a spatially and temporally defined health hazard can come into contact with man both spatially and temporally" (60, 61). The place of exposure (the spatial contact) and the duration of this (exposure) were therefore defined according to this "risk model." This process required a systematic and detailed description of each worker's daily tasks.

The work task was defined as including all tasks which the worker carried out during a workday (62, 80, 85); it was divided into subtasks for the uniform and representative assessment of the prevalence of health hazards and stress factors according to the "risk model" (appendix IV).

A subtask was a combination of work operations appropriate for the assessment of work conditions with respect to place and time. The main work areas of each worker were defined according to the subtasks. Thereafter the average duration of each subtask during the previous year was assessed. The author interviewed both the management and the workers about the average durations of the subtasks. The mean duration of an exposure in the work area of a subtask was in some cases shorter than the duration of the subtask itself. If so, it had to be assessed separately (appendix IV).

The same persons (the author, an industrial hygienist and a physiotherapist) surveyed all the work tasks according to a uniform procedure. One essential feature of the survey method was that it was carried out in two phases (two visits

to each workplace). This procedure enabled the surveyors to use the experience of the personnel in the workplace (appendix V), before the actual survey, to inform the personnel in good time about the objectives of the survey, to define the workers to be included in the survey uniformly, and to agree upon the date of the second visit to ensure that work tasks and conditions were as typical as possible.

This procedure facilitated the planning and implementation of measurements of physical and chemical factors. It was especially important for the representativity of the survey of the smallest workplaces, where a great daily variation in the work tasks was possible.

The actual survey of health hazards and stress factors during the second visit to the workplace lasted about 20 min per worker.

Health hazards and stress factors surveyed

Noise. The noise exposure of each worker was surveyed separately to assess the risk of noise-induced hearing loss. The mean noise level was assessed by measurements made in typical work areas. The A filter and predominantly the 200-ms time constant were used in the noise meter.[2] Impulse noise was measured with the 35-ms time constant. More-detailed descriptions of the measuring technique and of the calculation of the equivalent noise level can be found in the literature (14, 49, 67, 81). A noise level of at least 85 dB (leq) was defined as the risk level (19).

Illumination. The illumination was measured with a cosine corrigated luxmeter, the calibration of which was checked with parallel measurements.

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[2] Brüel & Kjaer types 2208 and 2209.

The level of illumination was evaluated on the basis of the following criteria: illumination in lux, reflection, evenness of distribution of the illumination, and the type and location of the light source used. On the basis of these criteria illumination was classified into three categories: illumination which fulfilled the minimum requirements (level 1), illumination with small or moderately severe deficiencies (level 2), and illumination with great deficiencies (level 3). The required minimum illumination (lux) was defined on the basis of the degree of accuracy needed in the work task, the degree of contrast between the object and the background, and the reflection coefficient of the background (39, 83). A more-detailed description of the measuring technique and of the evaluation criteria for the level of illumination has been presented elsewhere (36, 39, 81, 83).

Ultraviolet radiation. The "exposure"[3] to ultraviolet radiation was surveyed through observation of production methods and the interviewing of management and workers. The minimum "exposure" time was at least 30 min/d on the average. "Exposure" to radiation generated from another worker's work task (passive "exposure") was not taken into account (81).

Chemical factors. Chemical factors were surveyed qualitatively or quantitatively and evaluated on the basis of their toxic, sensitizing, and carcinogenic properties. The minimum criterion was that the exposure time lasted an average of at least 30 min/week (77).

Concentrations of volatile substances were measured with indicator tubes (Dräger) (44). No measurements were made if

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[3]The "exposure" to ultraviolet radiation was potential exposure rather than actual exposure because welding helmets were used regularly.

the concentration of the substance was obviously lower than half of the Finnish exposure limit value (FLV) because of the small amounts of the substance in use.

Exposure to toxic substances (36) was evaluated both according to the Finnish limit value for 8-h exposure (FLV_{8h}) and the Finnish limit value for 15-min exposure (FLV_{15min}) (21). An exposure was classified as a risk exposure if its concentration was at least 0.5 x FLV_{8h} or 0.5-2.0 x FLV_{15min}, the latter depending on the grade of toxicity[4] (I-IV) of the substance (36) (tables 4 & 5, appendix I). The evaluation of the hazardousness[4] of a substance measured with an indicator tube and classified according to both the FLV and the toxicity of the substance is presented in tables 4 and 5 in appendix I (36).

The composition of a chemical factor and the exposure time were assessed separately for each worker. The properties of substances with a possible adverse effect on health were obtained from the literature (27, 32, 55, 66, 69, 70). Chemicals factors were surveyed by an industrial hygienist, together with a physician trained in industrial hygiene.

Allergens were defined according to a list of allergens which included substances sensitizing the skin or respiratory tract (36, 86). Those workers whose contact with an allergen was recognized by both the physician and the industrial hygienist were defined as being exposed.

Carcinogens were defined according to a list of carcinogens (36, 86). This list contained only relatively well-known

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[4]Toxicity is the ability of a chemical to produce injury once it reaches a susceptible site in or on the body (17). Hazard is the probability that injury will be caused by the exposure (17).

carcinogens (N = 57). Only a few lists of carcinogens were available at the time of the survey. (None were Finnish.)

Dynamic work load. The work load was usually evaluated by a specially trained physiotherapist. The information was obtained by means of observation and interview, and the classifications were based on tables of energy expenditure in different work postures and work movements (43, 80). The tables were used as such in 20 % of the evaluations (N = 1,181). The rest of the evaluations was made with a set of descriptions about work postures and work movements in each work load category (light, moderately heavy or heavy) (42, 80). These descriptions were also based on tables of energy expenditure (43). Each worker's work was classified according to energy expenditure during the workday as light (below 145 W or 1,000 kJ), moderately heavy (145-218 W or 1000 - ≦ 1,500 kJ) or heavy (over 218 W or 1,500 kJ) (36).

Static work load. The physiotherapist described the static work load of each worker. The information was obtained by means of observation and interview. The average durations of the different work postures were assessed. The static work load was classified as heavy if it was due to large muscle groups and lasted for at least 4 h during a workday. Large muscle groups included the back muscles, the muscles of the lower limbs, and the muscles of both upper limbs and the shoulders (80).

Physical and chemical risk exposures. Workers' exposure to physical and chemical risks (19) was used as an indicator of the hygienic standard of the work conditions. Many workers were exposed to more than one risk. Therefore, the workers were also classified according to the number of risk exposures. A comparison was made of the standards reached in industrial hygiene in different types of industry and occupational groups. The number of risk exposures

per 100 workers was used as the indicator (53). Multiple exposures were taken into account with this indicator.

The prevalence of risk exposures was evaluated by the author after he carried out the industrial hygiene survey together with an industrial hygienist. Only the exposures described in the directives for periodic medical examinations ("which can cause a special or relevant hazard to the health of the workers")(19) were considered. Many exposures were clearly defined in the directives. For example, a noise level of at least 85 dB (leq) was considered a risk exposure with regard to noise-induced hearing loss, and toxic substances with concentrations above 0.5 x FLV_{8h} were risk exposures.[5] The definitions of some risk exposures were ambiguous and therefore had to be defined. For example, before exposure to hand vibration was considered a risk, a worker had to be exposed a minimum of 1 h on the average during the workday. Uncertain risk exposures were not classified as such. The majority of welding operations belonged to these. If, however, welding caused a special risk, such as exposure to ozone, which was defined in the directives for periodic medical examinations, it was classified as a risk exposure.

PERSONAL PROTECTION DEVICES

The need for personal protection devices was assessed for each worker separately by the industrial hygienist. The criteria for the necessity of personal protection devices were as follows: A health hazard could be reduced by the use of personal protection devices and the use of the devices did not make the performance of the work task more difficult.

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[5]This usage does not imply that the author regards the FLV concept, which accepts a health risk, as satisfactory (59).

The use of hearing protectors was considered to be necessary if the noise level exceeded 80 dB (leq). If the noise level was 80-90 dB (leq), the use of cotton wool or ear plugs was recommended. When the noise level exceeded 90 dB (leq), ear shields were recommended. Protective goggles were considered necessary if fast-moving, solid particles (eg, from grinding) were produced during the work task or if there was a risk of splashing irritating or corrosive substances. Protective gloves, rubber or plastic, were considered necessary if there was regular skin contact with corrosive, irritating, or sensitizing substances. The use of cartridge respirators against dust or volatile substances was considered necessary if a health hazard could be substantially diminished by the use of the devices. The assessment of the availability and use of personal protection devices was based on the author's observations and interviews.

QUESTIONNAIRES

Information about age, sex, length of service in the present occupation, demands of the work tasks, rheumatic complaints, adverse skin effects, etc, was obtained by means of a questionnaire filled out by the workers (appendix VI). Information about occupational health care was obtained from the authors's interviews of the employer (appendix VII).

OCCUPATIONAL TITLES DEFINED FOR OCCUPATIONAL HEALTH

General

One objective of this study (page 9)was a classification of workers according to occupational titles in a way that is relevant to occupational health. The occupational titles used in the workplaces were not satisfactory, and some weaknesses were also noted in the standard occupational classification (23, 35) (appendix VIII).

A method was developed for the classification of workers according to occupational health titles (OHTs). Those workers with sufficiently similar work tasks and production methods were grouped under the same occupational health title, as it was assumed that work tasks and production methods are relevant criteria for the homogenization of health hazards and stress factors in a group of workers. The production method was defined as including the following criteria: the technology, the degree of differentation of work tasks, and the level of mechanization of work.

The OHTs were combined into groups of OHTs (OHT group) according to the production process. A more-detailed account of the groupings is given in each part of the study.

The main difference between the classification according to OHT as compared to the customary occupational title (OT) was that OHTs were based on information obtained from the actual work tasks and production methods of the employees and not on the titles used in the workplaces. The differences between the OHTs and OTs have been summarized in appendix VIII.

Procedure

Information on each worker's production methods and work tasks (appendix IV) was obtained from observations of the production process and from interviews of the management and the workers during two visits to the workplace (fig 1). Information on the average durations of the use of the production methods was obtained from the catalogue of work tasks. Both the author and the industrial hygienist gathered information on the production methods of the workers.

The catalogue of work tasks (appendix IV) was completed by the author, and information on the production methods was

obtained before the survey of health hazards and stress factors. Thus all the information needed for the classification of workers under OHTs was obtained before the survey, and it was unaffected by the results of the survey. However, the workers were grouped under OHTs after the survey of all the workplaces for the sake of the uniformity of the grouping (fig 1).

The classification of workers under OHTs during 1977 was based solely on information on the work tasks and production methods of each worker, and the data concerning health hazards and stress factors (surveyed during 1976) was not considered at that time.

Phase	Year	Action
1.	1975	Classification according to type of industry
2.	1975	Sampling
3.	1976	First visit to the workplace - production process, technology - catalogue of work tasks
4.	1976	Second visit to the workplace - catalogue of work tasks - survey of health hazards and stress factors
5.	1977	Classification of workers according to the occupational health titles

Fig 1. Phases of the study.

The classifying of workers into OHTs is presented in detail in appendix IX.

CLASSIFICATION ACCORDING TO TYPE OF INDUSTRY

The standard industrial classification (SIC)(11, 75) was used for the classification of workplaces according to type of industry. In this classification the workplaces with the same main products are classified into the same type of industry.

OCCUPATIONAL STRUCTURE AND STRUCTURE ACCORDING TO TYPE OF INDUSTRY

Occupational structure was defined as the relative proportions of different occupational health titles (OHT) or title groups in a workplace or a group of workplaces such as a type of industry. The structure according to type of industry was defined analogously as the relative proportions of different types of industry in a group of workplaces.

STATISTICAL METHODS

Several significance testing and parameter estimation procedures were used in the different parts of the study to cater to the various sampling set-ups.

The methodology developed by Bryant et al (9, 13) was employed to estimate the prevalence of the health hazards and stress factors and their standard errors (deviations) among workers in random samples from different types of industry (appendix X).

The normal approximation of the confidence interval of a prevalence rate did not apply to many of the occupational groups because of the small value of np, the guantity to

which the error in the approximation is most sensitive (13). Instead, the limits were found from binomial tables.

The test for the significance of the difference in prevalence rates was based on a hypergeometric distribution using either Fisher's "exact" test (24) for small sample sizes or a standardized variate (g) with hypergeometric cumulants, which asymptotically follows a Gaussian (normal) distribution (57).

The differences between the occupational groups according to the prevalence rate of a risk factor or according to the frequency of risk factors (one worker could be exposed to 0-3 risk factors) were tested with a chi-square statistic (χ^2_k), its (k) "degrees of freedom" or "elements of information" depending on the dimensions of the contingency table arranged for testing. When k=1, eg, in a fourfold table, the Gaussian deviate g is equal to the square root of χ^2_k.

In situations where the distribution of the frequency of risk exposures was not known and where only the risk index could be calculated (by dividing the total number of exposures in the occupational group by the total number of workers in that group), the index was assumed to represent the mean of a (sum of) Poisson distribution(s). This formulation allowed the significance testing for the comparison between two occupational groups to be based on a test statistic which converges to a Gaussian distribution as the combined number of exposures becomes large (57). It should be stressed, however, that this test is dependent upon the chosen scale, ie, number of exposures per 100 workers. In cases where the actual group sizes were less than 100, the significance level attained (p-value) is overly liberal so that this test procedure must be regarded only as a crude approximation.

The estimation of the limits for the exposure index was

based on the Poisson tables (16). The estimate was always made on the basis of the number of exposures observed among the workers in a particular occupational group, and not on the basis of the index number. Underlying these estimates is the assumption that the distribution of the number of exposures follows a Poisson distribution. The tenability of a Poisson model for describing the frequencies of the risk exposures was tested (81), and it was found that this probability model could well be Poisson. McNemar's test (51) was mainly used to compare the difference in the occurrence of symptoms between individually matched groups of workers. This is a Gaussian deviate. The significance of the differences according to the distribution of the frequency of symptoms was assessed with the aid of Mantel's (47) extension of the Mantel-Haenszel procedure (48). The resulting test statistic follows a chi-square distribution with one degree of freedom.

In the calculation of the ordinary (unweighted) prevalence estimates the finite population correction factor $(N-n)/N$, where N is the size of the study population, was not included in the formula because N was not known exactly and the sampling fraction n/N remained low. Thus the value of the correction factor would probably have been close to unity and the size of the population as such would have had no direct effect on the standard error of the sample prevalence (13).

The printing shops were regarded as a separate homogeneous partitioned sample from the graphic industry, for which, as well as for occupational groups, ordinary (unweighted) prevalence estimates were calculated. The standard error of these estimates was calculated as the square root of $p(1-p)/(n-1)$, where p is prevalence and n is sample size. The finite population correction factor $(N-n)/N$, where N is

the size of the study population, was not included in the formula because N was not known exactly and the sampling fraction n/N remained low. Thus the value of the correction factor would probably have been close to unity and the size of the population as such would have had no direct effect on the standard error of the sample prevalence (13).

IV RESULTS

A. PREVALENCE OF HEALTH HAZARDS, STRESS FACTORS AND OCCUPATIONAL HEALTH CARE IN SMALL INDUSTRY

The international standard industrial classification is internationally used for the classification of information related to economic activity (75). Also, information important to occupational health, such as statistics on occupational accidents and occupational diseases, is classified according to the type of industry, based on the international standard (78).

The objective of this part of the study was to obtain information on the applicability of the classification according to the type of industry for the priorization of occupational health activities.

In this part of the study prevalence figures concerning the whole sample, the major types of industry in the sample, the occupational health services provided, and the use of personal protection devices are presented. The prevalence data was obtained with the methods used for the survey of health hazards and stress factors (page 14).

The material of this part of the study was a sample representing the small industry of Uusimaa; it has been presented on page 10. The stratification of the sample is shown according to type of industry in table 3 in appendix I, and the sampling method on page 11.

PREVALENCE OF HEALTH HAZARDS AND STRESS FACTORS IN SMALL INDUSTRY IN UUSIMAA

The results concerning the prevalence of health hazards and stress factors in small industry in Uusimaa are presented

in tables 6 and 7. Exposures with low prevalences (under 2 %) are not presented. Distributions of the health hazards and stress factors in table 6 are presented according to type of industry in tables 8-18 in appendix I. Prevalences from eight small types of industry have not been presented separately (12 workplaces and 145 production workers, table 3 in appendix I) because of insufficient representativity.

Thirty-two percent of the workers (N = 1,181) were exposed to a noise level of at least 85 dB (leq), 11 % to vibration of the upper extremities, 43 % to poor illumination, 7 % to ultraviolet radiation, 3 % to chemical risk exposures (page 17) according to the FLV_{8h}, 7 % to the chemical risk exposures according to the FLV_{15min}, 46 % to allergens (page 17), 22 % to carcinogens (page 17), 27 % to dynamically heavy work, and 32 % to statically heavy work.

An indicator was used for the assessment of the prevalence of risk exposures (page 18) in order to take into account a worker's exposure to many risks during the workday. The prevalence of risk exposures was 53 per 100 workers (table 6).

Nine percent of the workers (N = 1,181) were exposed to welding fumes, 2 % to hard brazing fumes, 3 % to soft brazing fumes, 5 % to inorganic lead, 4 % to chromium and nickel, 7 % to oil mist, 2 % to benzene, 3 % to pyrolysis products of plastics, 13 % to wood dust, 11 % to flour dust, and 6 % to silica dust (table 7).

Table 6. Prevalence of health hazards and stress factors in the small industry of Uusimaa.

Health hazard or stress factor	Small industry (1,181 workers)	
	Prevalence (%)	Standard error
Noise (leq ≧ 85 dB)	32	2.9
Vibration (upper extremities)	11	1.6
Illumination (poor)	43	3.0
Ultraviolet radiation	7	1.4
Chemical risk exposure ($FLV_{8\ h}$)	3	1.5
Chemical risk exposure ($FLV_{15\ min}$)	7	..
Allergens	46	..
Carcinogens	22	..
One risk exposure	30	2.4
Two risk exposures	7	1.4
Three risk exposures	3	0.7
Risk exposures per 100 workers	53	4.5
Heavy dynamic work	27	2.6
Heavy static work	32	2.7

Table 7. Exposure of workers to some chemical factors and dusts in the small industry of Uusimaa.[a]

Exposure	Small industry (1,181 workers)
	Prevalence (%)
Welding fumes	9
Hard brazing fumes[b]	2
Soft brazing fumes	3
Lead (inorganic)	5
Chromium, nickel	4
Oil mist	7
Benzene (in gasoline)	2
Pyrolysis products of plastics	3
Wood dust	13
Flour dust	11
Silica dust	6

[a] Sample distributions.
[b] Exposure to cadmium in 40 % (N = 24).

Noise

Exposure to a noise level of at least 85 dB (leq) was the most prevalent exposure to affect the index of the standard of industrial hygiene. There were great differences in noise exposure between different types of industry. In table 8 (appendix I), the exposure to noise is presented according to the major types of industry in the sample.

About a third (32 %) of the workers (N = 1,181) were exposed to a noise level of at least 85 dB (leq) during work.

In the manufacture of furniture, the manufacture of wood and wood products, and the manufacture of metal products, 60-80 % of the workers were exposed to a level of at least 85 dB (leq). In these types of industry exposure to a noise level of at least 100 dB (leq) was also the most prevalent. In the manufacture of other nonmetallic mineral products, exposure to noise may well have corresponded to that of the aforementioned types of industry, but the small number of workplaces (N = 3) resulted in insufficient valid data. In the printing industry and in the manufacture of machinery, 20-30 % of the workers were exposed to noise of at least 85 dB (leq). In the manufacture of plastic products, the manufacture of electrical apparatus, and the manufacture of textiles a significant proportion of the workers was exposed to at least 85 dB (leq) noise. In the manufacture of other chemical products and in food manufacturing, the prevalence of noise exposure of 85 dB (leq) was low. In the manufacture of wearing apparel (clothing) and in bakeries, exposure to this level of noise was rare (table 8, appendix I).

Short-term exposures to high noise levels were common in small industry. Only about 15 % of the workers were exposed to noise over 80 dB for the majority (6-8 h) of a workday. However, over 50 % of the workers were exposed to over 80 dB (leq) noise when short-term exposures to high noise levels were also taken into account.

Four percent of the workers (N = 1,181) were regularly exposed to impulse noise. It is quite possible that some 10 dB should be added to the noise level (leq) to compensate for predominantly impulse noise (5, 8). Noise levels based on impulse noise were not "corrected" in this survey.

STANDARD OF INDUSTRIAL HYGIENE ACCORDING TO TYPE OF INDUSTRY

There were great differences in the prevalence of risk

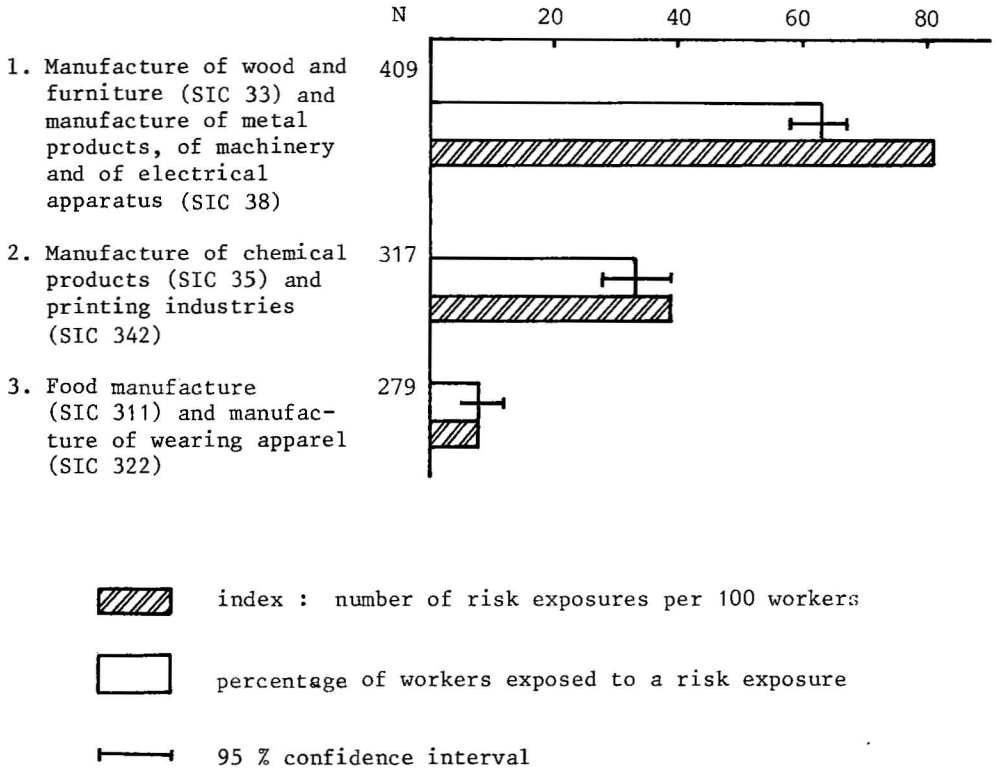
exposures according to the type of industry (tables 15 & 16, appendix I). On the basis of these differences the major industries of the sample could be classified into three groups which represent different standards of industrial hygiene (fig 1).

Two small industries, manufacture of textiles (N = 36) and manufacture of other nonmetallic mineral products (N = 16), were not included as representativity was considered insufficient.

OCCUPATIONAL HEALTH CARE

In 1976, in the small industries in Uusimaa employers had provided occupational health care in about 16 % (15.5 ± 3.9) of the workplaces (15.7 ± 1.4 % of the employees had access to occupational health services). In about 14 % (13.9 ± 3.8) the employer was planning to provide occupational health care, and in about 70 % of the workplaces occupational health care was not even planned (79).

The number of risk exposures per 100 workers was 74 (95 % confidence interval 62-86) in those workplaces which provided occupational health care and 49 (95 % confidence interval 40-58) in the workplaces which did not provide occupational health care ($p < 0.001$). The workplaces with access to occupational health care and those which planned to provide occupational health care also differed with respect to the prevalence of risk exposures ($p < 0.001$) (fig 2) (81).



Differences (g-statistics):

1 and 2 : $g=7.79$, $p<0.001$

2 and 3 : $g=7.45$, $p<0.001$

Fig 2. Standard of industrial hygiene according to type of industry in small industrial workplaces.

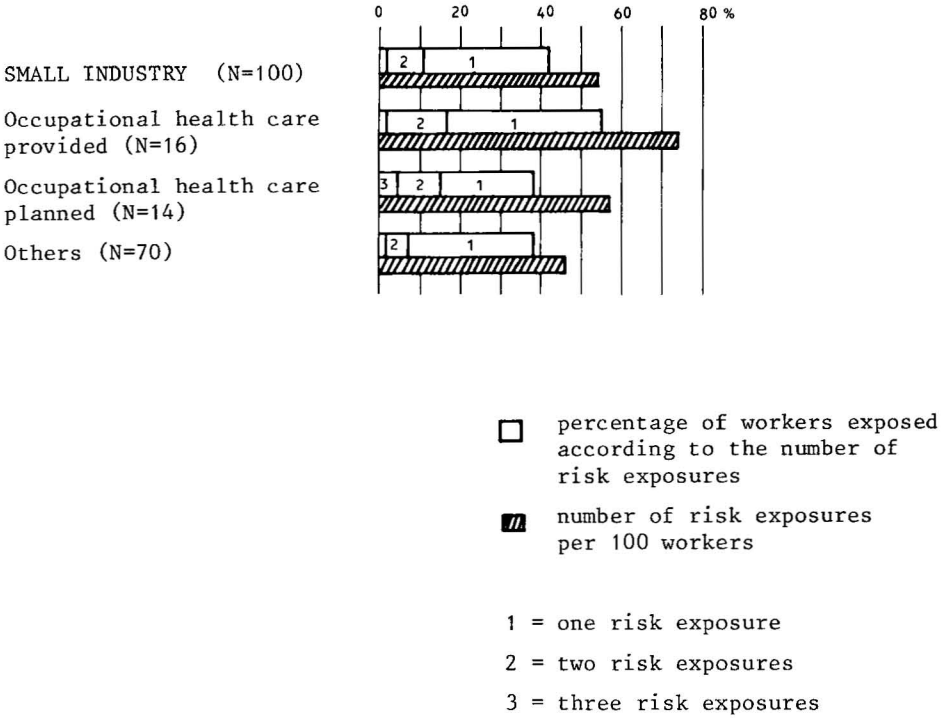


Fig 3. Standard of industrial hygiene according to the prevalence of risk exposures in the whole sample (estimated), in workplaces with occupational health care, in those planning to provide occupational health care, and in those not yet interested in providing occupational health care (sample distributions).

PERSONAL PROTECTION DEVICES

A personal protection device was considered necessary for 61 % of the workers (N = 1,181). The indicator of the necessity of a personal protection device was 97 (the number of devices per 100 workers). It was equally common to find that a personal protection device was available as to find that it was not available. A little more than half of the personal protection devices available were in use (table 19, appendix I).

The necessity, availability, and usage of different kinds of personal protection devices are presented in fig 4. Cartridge respirators were the least available personal protection device, and ear shields were the least used.

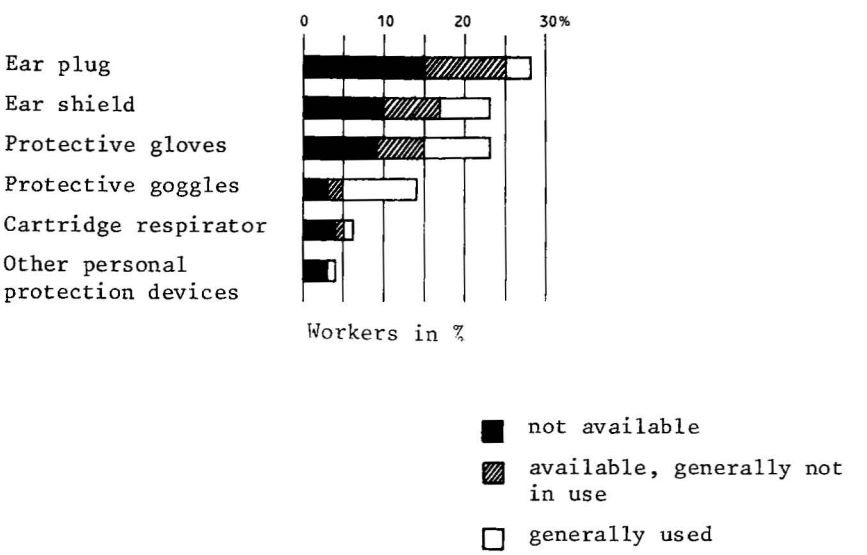


Fig 4. The necessity, availability and use of personal protection devices according to the type of device in the sample representing small industry.

DISCUSSION

The types of industry classified into the same group according to the standard of industrial hygiene differed from each other somewhat with respect to the standard of industrial hygiene. However, the differences between the three groups were greater than the differences within the groups. The range in the standard of industrial hygiene (index) was 76-99 for the first group, 35-52 for the second group, and 6-12 for the third group.

The classification according to the standard of industrial hygiene may be regarded as fairly accurate with regard to the three smallest types of industry (the manufacture of wood and wood products, the manufacture of chemical products and the manufacture of plastic products) if the proportions of workers exposed is used as a second criterion. The differences in the proportions of workers exposed were greater between the three groups representing different levels in the standard of industrial hygiene and smaller within these groups than corresponding differences in the index figures (tables 16, 20 & 21, appendix I).

For the whole sample, the index of the standard of industrial hygiene was 53. For the group of industries with the most prevalent risk exposures the value of the index was 81 (41 % of the workers, N = 1,005), and for the group of industries with the best hygienic conditions as far as risk exposures were concerned it was only 8 (32 % of the workers, N = 1,005). The index of the whole sample (53) did not even represent the second of the three groups of industries where the index value was 39 (27 % of the workers, N = 1,005). The same conclusion about the heterogeneity of the industry as a whole with regard to the prevalence of risk exposures can be drawn from a comparison of the proportions of exposed workers in the whole sample (40 %) to those in the three different groups according to the standard of

industrial hygiene (63, 33 and 8 %) (tables 16 & 20, appendix I).

In earlier studies in the United States clear differences in the standard of industrial hygiene have been shown between different types of industry in a stratification where manufacturing was one entity (53, 76). There were also clear differences in the prevalence of risk factors according to type of industry within manufacturing in a Swedish study (74). However, different types of small industry have not, to the best of the author's knowledge, been previously classified according to the standard of industrial hygiene based on the prevalence of risk exposures.

It is interesting to note that an estimation of the types of industry with the most prevalent risks in the whole industry, which was based on statistics about occupational diseases, yielded about the same results (22) as the classification according to the standard of industrial hygiene used in this study (page 33) (81).

Within small industry, selection of workplaces into occupational health care from the point of view of labor protection had already taken place before the introduction of occupational health care legislation, as the standard of industrial hygiene was lower within than outside of provided occupational health care.

Cartridge respirators were the least available personal protection device, and ear shields were the least used. Improving the availability and the use of personal protection devices could economically prevent the characteristic peak exposures of small industry to a considerable extent until technical improvements are possible.

Personal protection devices are also a good indicator of labor protection, because their necessity indicates the

prevalence of health hazards, and their availability and use indicate the awareness of health hazards and the motivation to prevent them in the workplaces.

B. CLASSIFICATION ACCORDING TO TYPE OF INDUSTRY IN THREE DIFFERENT TYPES OF METAL INDUSTRY

The metal industries belonged to the group of workplaces with the most prevalent health hazards (page 33), and the most important types of industry within it were the manufacture of metal products, the manufacture of machinery and the manufacture of electrical apparatus (table 3, appendix I).

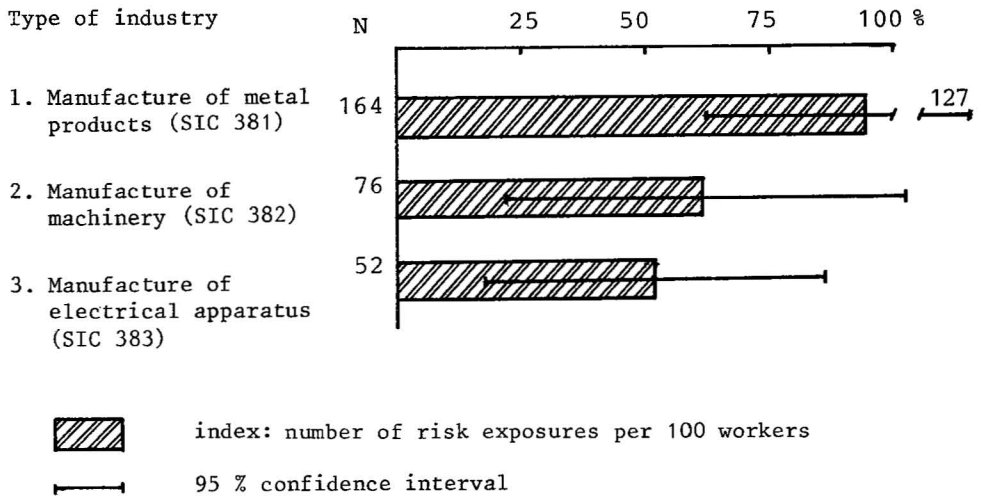
The purpose of this part of the study was to obtain information about the applicability of the standard industrial classification within the small metal industry by means of the prevalence data presented in part A of section IV.

The material consisted of the major types of small metal industry (SIC 381-383). The metal industry was well suited for a deeper study into the validity of the industrial classification based on the nature of the product, because the same type of industry (SIC 38) was divided into three subindustries (SIC 381-383) with different major products. Industries 384 (SIC) and 385 (SIC) were not included because of the scarcity of workplaces involved in them. The material and the sampling method have been presented in detail on pages 11 and 12.

The prevalences of risk exposures and physically heavy work were used as indices of the level of work conditions. The number of risk exposures (page 18) per 100 workers was used as an index of the industrial hygiene standard because the same worker was often exposed to more than one risk exposure. An index of the physical work load (appendix X) was constructed on the basis of dynamic work load and static work load (page 18).

STANDARD OF INDUSTRIAL HYGIENE

There were great differences in the standard of industrial hygiene between different types of industry within the metal industry (SIC 38) (fig 5 and table 21 in appendix I). Risk exposures accumulated in the manufacture of metal products, where the index of the prevalence of risk exposures was 95, ie, nearly twice as high as that of the manufacture of electrical apparatus (risk index = 53).



Differences (g-statistics):

1 and 2 : g=2.58, p<0.01
2 and 3 : g=0.90, NS
1 and 3 : g=3.46, p<0.001

Fig 5. Index of risk exposures according to different types of industry (SIC 381-383) within the metal industry (SIC 38).

PHYSICAL WORK LOAD

The index of physical work load diminished when shifted from the manufacture of metal products to the manufacture of electrical apparatus (fig 6 and table 22 in appendix I). This tendency was due to dynamically heavy work being common in the manufacture of metal products but not common in the manufacture of electrical apparatus (fig 7 and table 23 in appendix I). The static work load was, when the sources of error are taken into consideration, about the same in the three types of industry (fig 7 and table 24 in appendix I). In other words, the relative importance of the static work load grew in the direction of increased processing in the three types of metal industry concomitantly with the diminishing dynamic work load.

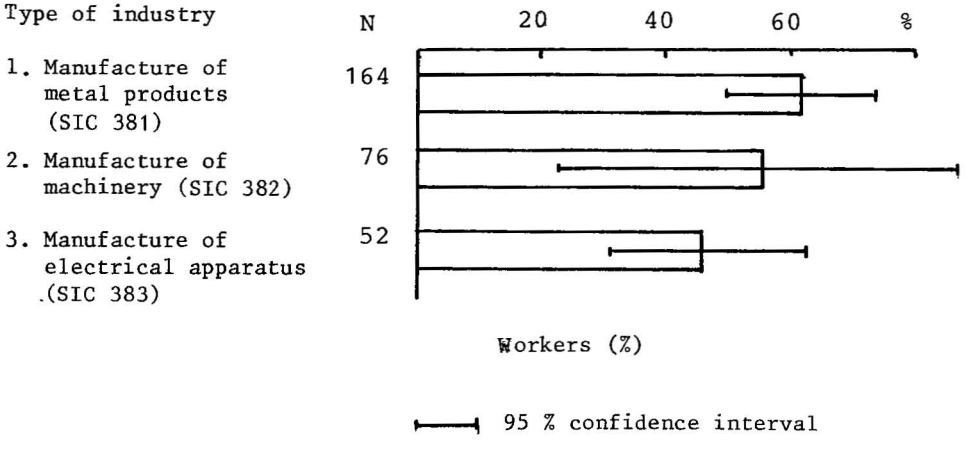
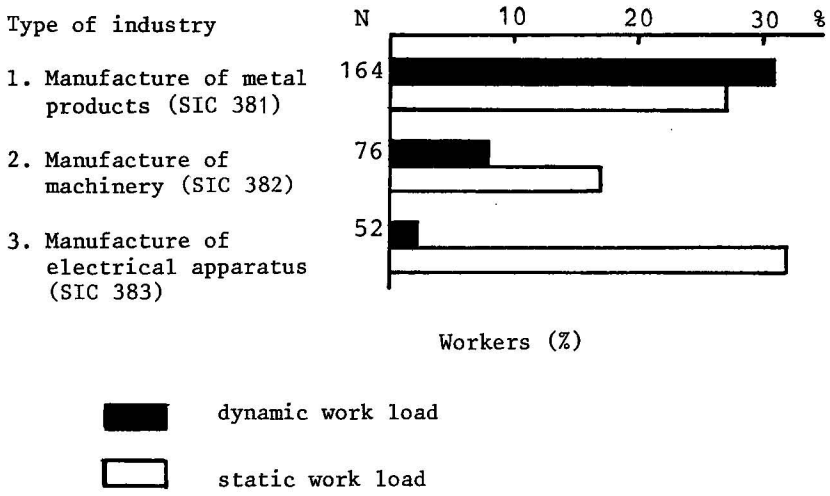


Fig 6. Prevalence of workers with a high index of physical work load in different types of industry (SIC 381-383) within the metal industry (SIC 38).



Differences (g-statistics) in dynamic work load (see fig 6):

1 and 2 : $g=3.92$, $p<0.001$
2 and 3 : $g=1.45$, NS

Fig 7. Prevalence of workers with heavy dynamic and static work loads, respectively, in different types of industry (SIC 381-383) within the metal industry (SIC 38).

DISCUSSION

The differences between the manufacture of machinery (SIC 382) and the manufacture of electrical apparatus (SIC 383) in the standard of industrial hygiene and physical work load cannot be considered real differences, as they were not statistically significant. Thus the three subindustries (SIC 381-383) of the same type of industry (SIC 38) were classifiable into two groups according to the indicators of health hazards and stress factors. This result might well be due to the small sample size rather than to the classification according to the type of industry, but the results indicate that the differences between the two types of industry (SIC 382 and 383) are rather small when measured with the indicators of this study (page 18).

The index of physical work load was crude (appendix XI), and it cannot be claimed to take the interaction of dynamic and static work loads into consideration in the correct proportions (37). The index was used to clarify the effect of static work load on physical work load. As work load diminishes dynamically, the physical work load does not diminish correspondingly unless the static work load diminishes at the same time.

Both the standard of industrial hygiene became better (page 39) and the physical work load became smaller (page 40) as the degree of processing increased, from the manufacture of metal products (SIC 381) to the manufacture of machinery (SIC 382) and to the manufacture of electrical apparatus (SIC 383) (corresponding to the beginning of a production process through to the end, respectively) (40).

The results support the view that an increase in the degree of processing within the small metal industry (SIC 381-383) leads to both a decrease in the prevalence of risk exposures and a decrease in the prevalence of heavy physical work load.

C. OCCUPATIONAL HEALTH TITLE AS A CLASSIFICATION FOR THE SURVEY OF HEALTH HAZARDS AND STRESS FACTORS IN TWO TYPES OF METAL INDUSTRY

Both the study and prevention of risk factors are promoted if groups of workers homogeneous in respect to the prevalence of risk factors can be identified. Groups of workers which are the most and least exposed to a specific exposure can then be defined, and resources allocated correspondingly.

The purpose of this part of the study (part C) was to test whether a classification based on the nature of the production method (occupational health title) was better than that based on the nature of the product (type of industry).

The first problem to be studied was whether it was possible to obtain more information on health hazards and stress factors with the classification according to occupation (OHT) planned for this study (page 20) than with the classification according to type of industry.

Second, the prevalence of health hazards and stress factors was also studied according to OHTs in order to relate the differences observed between the two types of metal industry to differences in their occupational structures.

The manufacture of metal products, machinery, and equipment (SIC 38) was studied more closely, as systematic differences in the prevalences of health hazards had been observed between its major subindustries (381-383). The manufacture of electrical apparatus (SIC 383) was not included in this deeper study for the following two reasons: (i) the differences between it and the manufacture of machinery (SIC 382) were small (page 39) and (ii) in the manufacture of electrical apparatus there were small OHT groups which could not be linked to the OHT groups of the manufacture of metal products and machinery (because of substantial differences in the

level of mechanization or the degree of differentiation of the work tasks).

The material and sampling method of this part of the study have been presented on pages 11 and 12.

OCCUPATIONAL HEALTH TITLE GROUPS

Workers were classified according to OHTs on the basis of the work task and the production methods they used (page 20 and appendix IX). For example, those workers who welded for at least 4 h daily were called welders. The OHTs were classified according to the production process into six OHT groups (table 25). The OHT groups were also combined into three phases of production (OHT groups 1-2, 3-4 and 5-6). Examples of OHTs are presented in appendix XII.

Table 25. Numbers of workers in different occupational health title groups within the manufacture (mfg) of metal products and the manufacture of machinery.

Occupational health title groups	Type of industry	
	Mfg of metal products Number of workers	Mfg of machinery Number of workers
1 Cutting, sheet metal forming: sheet metal cutter, metal presser	32	5
2 Assembly: welder, sheet metal worker	54	5
3 Metal processing (nonautomatic): latheman, miller, driller	16	24
4 Assembly: assembler	6	25
5 Surface treatment: electroplater, spray painter	20	4
6 Others: warehouse worker, packager	36	13
Total	164	76

COMPARISON OF TYPE OF INDUSTRY AND OCCUPATIONAL HEALTH TITLE GROUP AS CLASSIFICATIONS FOR FORMING GROUPS OF WORKERS

The procedure for comparing the type of industry and the OHT is presented in fig 8. The same group of workplaces (SIC 381-382) was classified according to the type of industry (into SIC 381 and SIC 382) and according to OHT grouping (mostly into OHT 1-3 and 4-6). The two classifications were compared according to yield of information on the prevalence of health hazards and stress factors.

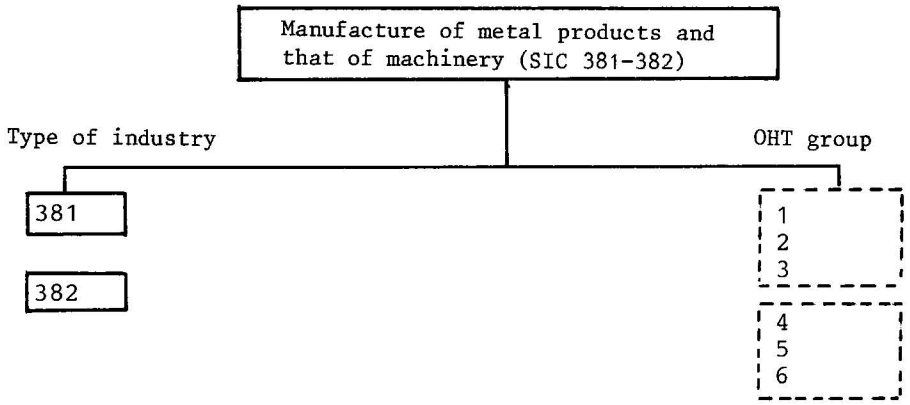


Fig 8. Procedure for the comparison of the type of industry and occupational health title.

Table 26. Prevalence of noise exposure ≥ 85 dB (leq) according to the type of industry and occupational health title (OHT) in the manufacture of metal products and machinery.

Group of workers	N	Prevalence (%)	Range within the group of workers
SIC 381-382	240	48	13 - 92
SIC 381	164	59	10 - 93
SIC 382	76	25	8 - 80
OHT 1-3	136	83	65 - 92
OHT 4-6	104	16	13 - 18

The discriminating power of the OHT group with respect to, eg, noise exposure was better than that of the classification according to type of industry. In the SIC 381-382 types of industry 48 % of the workers (N = 240) were exposed to a noise level of at least 85 dB (leq). After classification according to type of industry 59 % of the workers in SIC 381 (N = 164) and 25 % of the workers in SIC 382 (N = 76) were exposed to this noise level. However after classification according to OHTs 83 % of the workers in OHT groups 1-3 (N = 136) and 16 % of the workers in OHT groups 4-6 (N = 104) were exposed to the aforementioned noise level in industries SIC 381-382. The difference in the prevalence of noise exposure within the same group of workers (SIC 381-382) was thus greater according to OHTs (83 - 16 % = 67 %) than according to types of industry (59 - 25 % = 34 %)(table 26).

The OHT groups were more homogeneous with respect to noise exposure than the types of industries. Within OHT groups 1-3 the range of the prevalence of noise exposure was

65-92 %, and correspondingly within OHT groups 4-6 13-18 %. The ranges within types of industry were much greater: 10-93 % within SIC 381 and 8-80 % within SIC 382 (table 26).

When classifications according to type of industry and according to OHTs were compared (fig 8) with respect to the prevalence of risk exposures, high dynamic work load and specific exposures such as lead and ultraviolet radiation, the results were the same as the ones presented corcerning noise exposure, ie, the classification according to OHTs was better than that according to type of industry with regard to discriminating power, homogeneity, and definition of the workers exposed (tables 27-30, appendix I).

OCCUPATIONAL STRUCTURE AND THE PREVALENCE OF HEALTH HAZARDS AND STRESS FACTORS

The problem was whether the observed differences in the prevalence of health hazards and stress factors between the two types of metal industry (table 31 in text and tables 32 & 33 in appendix I) could be related to the different occupational structures based on OHTs between the two types of industry under study. A valid relationship between occupational structure (page 23) and the differences in work conditions between the two groups of workplaces (types of industry) can only exist under the following three conditions: (i) if occupational structures of the two types of industry are different, (ii) if different occupational title groups in the two industries are different with regard to the surveyed health hazards and stress factors, and (iii) if the same OHT groups of the two industries are similar with regard to the health hazards and stress factors surveyed.

Table 31. Prevalence of health hazards and stress factors in the manufacture (mfg) of metal products (prod) and the manufacture of machinery (mach).

Health hazard or stress factor	Mfg of metal prod (N=164)		Mfg of mach (N=76)		
	Prevalence (%)	Standard error	Prevalence (%)	Standard error	
Noise (leq ≧ 85 dB)	59	(7.4)	25	(8.8)	xxx
Illumination (poor)	58	(6.9)	28	(13.2)	xxx
Ultraviolet radiation	29	(7.0)	9	(2.9)	xxx
Toxic substances	32	(3.7)[a]	18	(4.4)[a]	x
Lead	14	(2.7)[a]	1	(1.1)[a]	xx
Allergens	12	(2.5)[a]	38	(5.6)[a]	xxx
Carcinogens	18	(3.0)[a]	37	(5.6)[a]	xx
Chromium, nickel	4	(1.5)[a]	25	(5.0)[a]	xxx
Risk exposures	66	(3.7)[a]	43	(5.7)[a]	xx
Physical risk exposures	62	(3.8)[a]	38	(5.6)[a]	xxx
Noise (leq ≧ 85 dB) and toxic risk exposure	16	(2.9)[a]	3	(2.0)[a]	xx

[a] Calculated directly from the sample: $s_p = \sqrt{p \cdot q/(n-1)}$.
x = p<0.05
xx = p<0.01
xxx = p<0.001

The proportions of nearly all the OHT groups following the production process (1-5) were different in the manufacture of metal products as compared to the manufacture of machinery (table 34). In the manufacture of metal products 52 %, and in the manufacture of machinery 14 %, of the workers worked

in OHT groups in the beginning of the production process (groups 1-2). In the manufacture of metal products 14 % and in the manufacture of machinery 64 %, of the workers worked in OHT groups in the middle of the production process (groups 3-4) (table 34).

Therefore the first prerequisite given on page 47 in order to relate the differences between the two types of industry (table 31) to the differences in their occupational structures was met.

Table 34. Differences in the occupational structures of the manufacture (mfg) of metal products and the manufacture of machinery.

Occupational health title group	Type of industry		
	Mfg of metal products (N=164)	Mfg of machinery (N=76)	
	Workers (%)	Workers (%)	
1 Cutting or forming	19	7	
2 Assembly (welding)	33	7	xxx
3 Metal processing	10	31	xxx
4 Assembly	4	33	xxx
5 Surface treatment	12	5	
6 Other work	22	17	
	100	100	
1-2	52	14	xxx
3-4	14	64	xxx
5-6	34	22	
	100	100	

xxx = $p<0.001$

In the study of the differences in the prevalence of health hazards and stress factors between the different OHT groups, the same OHT groups in the manufacture of metal products and in that of machinery were combined to obtain larger OHT groups for the comparison. The occupational classification following the production process has been presented on page 44.

Noise. In OHT groups 1-3, 65-92 % and, in OHT groups 4-6, 13-18 % of the workers were exposed to noise (leq ≥ 85 dB). In OHT groups 1 and 2 noise exposure was significantly more prevalent than in OHT group 3 and also more prevalent in group 3 than in 4 (table 35).

Illumination. Fifty-seven percent of the workers in OHT group 1, 81 % of group 2, 13 % of group 3, and 52 % of group 4 had poor illumination (table 34). In the combined OHT groups 1 and 2 poor illumination was highly significantly more prevalent than in the combined groups 3 and 4 (table 36).

Ultraviolet radiation. The potential exposure to ultraviolet radiation was concentrated in the first two OHT groups. In OHT group 2 (assembly), 76 % and, in group 1, 19 % of the workers were potentially exposed to ultraviolet radiation (table 37).

Risk exposures. The prevalence of physical and chemical risk exposures (page 18) per 100 workers was 131 in the three first, and 42 in the last three OHT groups, the difference being highly significant ($\chi^2=72.62$, $p<0.001$). OHT groups 1-2 and 3-4 also differed from each other highly significantly ($\chi^2=31.12$, $p<0.001$) (fig 9 and table 38 in appendix I).

Dynamic work load. In OHT groups 1-2 36 %, in groups 3-4 only 4 %, and groups 5-6 40 % of the workers did dynamically heavy work (table 39).

Table 35. Prevalence of noise exposure of at least 85 dB (leq) in the manufacture of metal products and machinery according to occupational health title group.

Occupational health title group	Number of workers	Prevalence (%) of noise ≧85 dB (leq)	95 % confidence interval
1	37	89	75 - 97
2	59	92	81 - 97
3	40	65	48 - 79
4	31	13	4 - 30
5	22	18	5 - 40
6	51	18	8 - 31
1-2	96	91	83 - 96
3-4	71	42	31 - 55
5-6	73	18	10 - 29

Differences (g-statistics):

1 vs 3: g=2.49, p<0.02
3 vs 4: g=4.38, p<0.001
1-2 vs 3-4: g=6.73, p<0.001
3-4 vs 5-6: g=3.19, p<0.002

Table 36. Prevalence of workers with poor illumination in the manutacture of metal products and machinery according to occupational health title group.

Occupational health title group	Number of workers	Prevalence (%) of poor illumination	95 % confidence interval
1	37	57	40 - 73
2	59	81	69 - 90
3	39	13	4 - 27
4	31	52	33 - 70
5	22	32	14 - 55
6	49	33	20 - 48
1-2	96	72	62 - 81
3-4	70	30	20 - 42
5-6	71	32	22 - 45

Differences (g-statistics):

1 vs 2: g=2.60, p<0.01

3 vs 4: g=3.49, p<0.001

1-2 vs 3-4: g=5.33, p<0.001

Table 37. Prevalence of workers exposed to ultraviolet radiation (UV) in the manufacture of metal products and machinery according to occupational health title group.

Occupational health title group	Number of workers	Prevalence (%) of UV exposure	95 % confidence interval
1	37	19	8 - 35
2	59	76	63 - 86
3-6	144	4	2 - 9

Differences (g-statistics):

1 vs 2 : g=5.46, p<0.001

1 vs 3-6: g=3.09, p<0.01

Table 39. Prevalence of heavy dynamic work in the manufacture of metal products and machinery according to occupational health title group.

Occupational health title group	Number of workers	Prevalence (%) of heavy work	95 % confidence interval
1-2	96	36	27 - 47
3-4	71	4	1 - 12
5-6	73	40	28 - 52

Difference 1-2 vs 3-4 (g-statistics): g=4.90, p<0.001

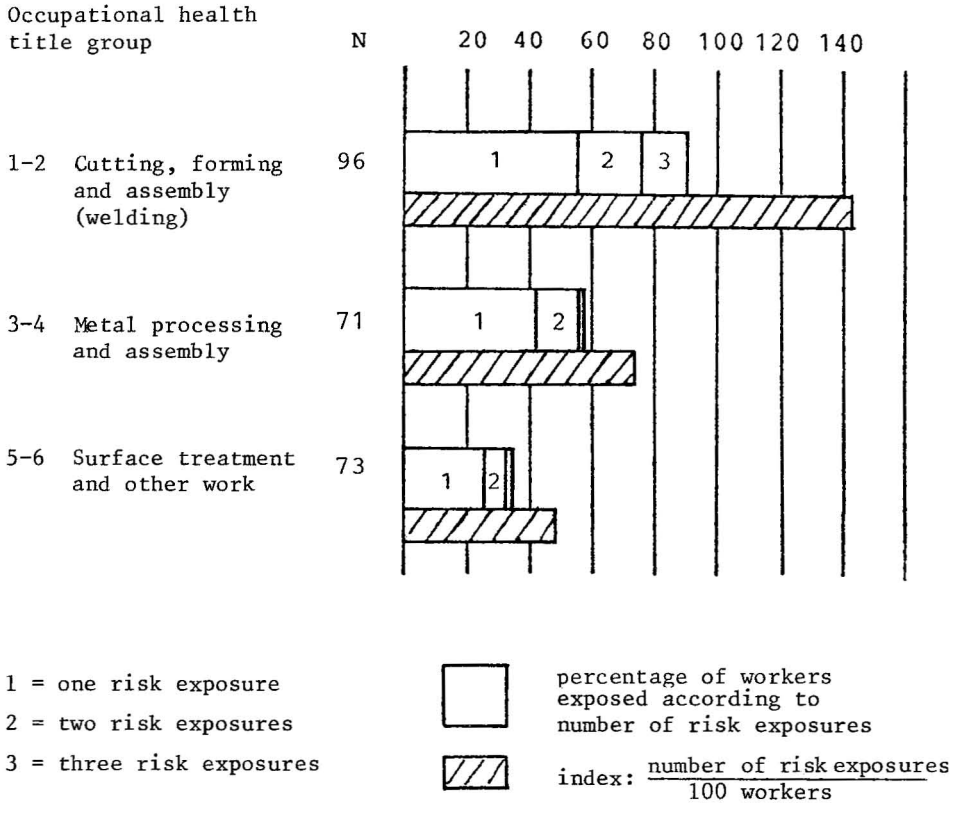


Fig 9. Prevalence of risk exposures according to their number and as an index per 100 workers in the manufacture of metal products and machinery according to occupational health title groups.

Summary of the results. There were statistically significant differences between the OHT groups concerning the prevalence of the health hazards and stress factors (or their indicators) surveyed. The assumption that most of the differences between the two types of industry were related to the differences in their occupational structures proved to be valid as far as the second prerequisite was concerned, ie, that different OHTs were different with regard to health hazards and stress factors.

The third and final condition to be met in order to relate the differences in the prevalence of health hazards and stress factors between the two types of industry to their occupational structures was (page 47) that the same OHT groups of the two types of industry must be sufficiently homogeneous with regard to the prevalence of health hazards and stress factors.

Noise. In both types of industry the exposure to a noise level of at least 85 dB (leq) was about the same in the same combined OHT groups (1-2, 3-4 and 5-6)(table 40). In the manufacture of metal products 53 % and in the manufacture of machinery only 14 % of the workers belonged to groups 1-2 (page 49), in which the large majority of workers were exposed to a noise level of at least 85 dB (leq). However, in the manufacture of machinery 65 % and in the manufacture of metal products only 14 % of the workers belonged to groups 3-4, in which less than one-half of the workers were exposed to a noise level of at least 85 dB (leq).

Ultraviolet radiation. In both types of industry the same OHT groups were potentially exposed to ultraviolet radiation (table 39). In group 2, 76 % and, in group 1, 19 % of the workers (N = 59 and 37, respectively) were potentially exposed to ultraviolet radiation. In the manufacture of metal products and in the

manufacture of machinery only 14 % of the workers (N = 164 and 76, respectively) belonged to groups 1-2.

Illumination. In both types of industry the prevalence of poor illumination was about the same in the same combined OHT groups (1-2, 3-4 and 5-6)(table 42). Thus the reasoning applied to noise applies to illumination as well.

Risk exposures. In both types of industry the first four OHT groups were almost similar with regard to the prevalence of risk exposures (table 43). In the manufacture of metal products 33 % and in the manufacture of machinery 7 % of the workers (N = 164 and 76, respectively) belonged to OHT group 2 with the most prevalent exposures (risk index 164). Correspondingly in the manufacture of machinery 33 % and in the manufacture of metal products 4 % of the workers belonged to OHT group 4 with the least prevalent risk exposures (risk index 32).

Allergens and carcinogens. The same OHT groups in the two types of industry were different with respect to the prevalence of allergens (table 44) and carcinogens (table 45). Therefore the differences between the types of industry (page 48) were not related to their occupational structures.

Dynamic work load. In both types of industry heavy dynamic work was rare in OHT groups 3-4 (table 46). In the manufacture of machinery OHT groups 3-4 consisted of 64 % and in the production of metal products only 14 % of all the workers (N = 76 and 164, respectively).

Summary of the results. The differences in the prevalence of most of the health hazards and stress factors surveyed (noise, poor illumination, ultraviolet radiation, risk exposures, and heavy dynamic work) between the two types of metal industry were related to the different occupational structures of these industries.

Table 40. Workers' exposure to a noise level of at least 85 dB (leq) according to occupational title group in the manufacture (mfg) of metal products (prod) and machinery.

Occupational health title group	Mfg of metal prod		Mfg of machinery	
	Workers (N)	Noise≧85dB(leq) (Number of workers)	Workers (N)	Noise≧85dB(leq) (Number of workers)
1	32	30	5	3
2	54	50	5	4
3	16	11	24	15
4	6	2	25	2
5	20	2	2	2
6	36	7	15	2
	164	102	76	28

Table 41. Workers' exposure to ultraviolet (UV) radiation according to occupational health title group in the manufacture (mfg) of metal products (prod) and machinery.

Occupational health title group	Mfg of metal prod		Mfg of machinery	
	Workers (N)	UV exposure (Number of workers)	Workers (N)	UV exposure (Number of workers)
1	32	6	5	1
2	54	42	5	3
3	16	0	24	0
4	6	1	25	1
5	20	0	2	0
6	36	1	15	3
	164	50	76	8

Table 42. Workers who had poor illumination according to occupational health title group in the manufacture (mfg) of metal products (prod) and machinery.

Occupational health title group	Mfg of metal prod		Mfg of machinery	
	Workers (N)	Poor illumination (Number of workers)	Workers (N)	Poor illumination (Number of workers)
1	32	18	5	3
2	54	45	5	3
3	16	3	23	2
4	6	2	25	14
5	20	6	2	1
6	35	13	14	3
	163	87	74	26

Table 43. Prevalence of risk exposures per 100 workers according to occupational health title group in the manufacture (mfg) of metal products (prod) and machinery.

Occupational health title group	Mfg of metal prod (N=164)		Mfg of machinery (N=76)	
	Workers (N)	Risk exposures per 100 workers	Workers (N)	Risk exposures per 100 workers
1	32	106	5	100
2	54	161	5	200
3	16	94	24	113
4	6	33	25	32
5	20	50	2	300
6	36	39	15	27

Table 44. Workers' exposure to allergens according to occupational health title group in the manufacture (mfg) of metal products (prod) and machinery.

Occupational health title group	Mfg of metal prod		Mfg of machinery	
	Workers (N)	Allergens (N)	Workers (N)	Allergens (N)
1	32	1	5	4
2	54	18	5	7
3	16	1	24	10
4	6	0	25	10
5	20	5	2	0
6	36	3	15	4

Table 45. Workers' exposure to carcinogens according to occupational health title group in the manufacture (mfg) of metal products (prod) and machinery.

Occupational health title group	Mfg of metal prod		Mfg of machinery	
	Workers (N)	Carcinogens (N)	Workers (N)	Carcinogens (N)
1	32	7	5	5
2	54	12	5	7
3	16	7	24	24
4	6	0	25	11
5	20	5	2	0
6	36	3	15	0

Table 46. Heavy dynamic work according to occupational health title group in the manufacture (mfg) of metal products (prod) and machinery.

Occupational health title group	Mfg of metal prod		Mfg of machinery	
	Workers (N)	Heavy work (Number of workers)	Workers (N)	Heavy work (Number of workers)
1	32	13	5	0
2	54	21	5	1
3	16	1	24	1
4	6	0	25	1
5	20	12	2	1
6	36	11	15	5

DISCUSSION

The classification according to OHTs proved to be better than that according to type of industry in the survey of health hazards and stress factors (risk exposures, heavy dynamic work, noise, and ultraviolet radiation) in the small metal industry. In other words the weakness of the classification of workers according to type of industry was shown by classification under OHTs.

When the same OHT groups of two types of small metal industry (SIC 381 and 382) were compared, the workers classified into the same OHT group proved to be exposed to similar health hazards and stress factors and, in general, to a similar extent (except for allergens and carcinogens) (pages 55-56). It should be noted that groups 5-6 cannot be regarded as "same OHT groups" in the two types of industry since they contained "other work" which consisted of workers who were not classifiable in actual OHT groups 1-5.

The similarity of the same OHTs in the two types of industry with regard to the majority of the surveyed health hazards and stress factors cannot be regarded as certain as the OHTs were too small in one of the two types of industry. But it is to be noted that the same OHTs in the two types of industry were consistently similar with respect to most of the factors surveyed. These results suggest that the same OHTs may well be similar with regard to the prevalence of health hazards and stress factors also in other types of industry.

D. CHARACTERIZATION OF EXPOSURE ACCORDING TO BOTH TYPE OF INDUSTRY AND OCCUPATIONAL HEALTH TITLE

In previous parts of the study, prevalences of health hazards and stress factors were reported according to type of industry and occupational health title in order to evaluate these classifications for the assessment of occupational health problems.

In this part of the study classifications were not compared with each other but were used simultaneously in order to develop systematics for the characterization of the prevalence of health hazards and stress factors. For this purpose printing shops were compared to other types of industry, and distributions according to OHT groups are presented for the printing shops.

The printing industry was included in this study because it was one of the largest types of industry in the sample (table 3, appendix I) and very different, with regard to production methods, from the other types of industry in the study. The sampled population and the sample are presented on page 13. Two workplaces were not included in the material (a silkscreen printing shop and a bindery) because of small occupational health title groups that could not be reasonably linked to the OHT groups of the relief or offset printing shops.

OCCUPATIONAL HEALTH TITLE GROUPS

The workers were classified according to OHTs on the basis of their production methods and work tasks. To be classified under an OHT the worker had to use the production method typical for the OHT for at least 4h/d. Of the workers (N = 171), 85 % were classified into one of these groups. The rest of the workers had too many subtasks to belong to an an OHT. In addition there were less than ten workers in some OHT groups. Therefore the initial OHTs were combined into five groups of OHTs that followed the production process (table 47). Of the workers (N = 171), 94 % were classified into an OHT group. Examples of classification according to OHTs are presented in appendix XIII.

Table 47. Grouping of workers in printing shops according to occupational health title group

Occupational health title group	Number of workers	Occupational health title
1 Typesetting	28	Typesetter (machine) Typesetter (manual)
2 Photographing, posting	31	Photographer, posting
3 Cutting	14	Paper cutter
4 Printing	56	Offset printer, relief printer
5 Binding	31	Binder, folding machine operator
6 Other work	11	
Total	171	

EXPOSURE WITH LOW SPECIFICITY ACCORDING TO BOTH TYPE OF INDUSTRY AND OCCUPATIONAL HEALTH TITLE GROUP

Of all the workers in the printing shops, 28 % (95 % confidence interval 19-37 %) was exposed to a noise level of at least 85 dB (leq). In the whole sample the corresponding figure was 32 % (95 % confidence interval 26-38 %). Of the 12 types of industry in the sample, the proportion of workers exposed to a noise level of at least 85 dB (leq) was less than 10 % in only two types of industry, the manufacture of food products (SIC 311) and the manufacture of wearing apparel (SIC 322) (81). As noise exposure was common in most types of industry, its specificity according to type of industry was low.

Within printing shops, exposure to a noise level of at least 85 dB (leq) was common in three of the five OHT groups (table 48). Therefore noise provided an example of an exposure, the specificity of which was low for printing shops both with respect to type of industry and OHTs.

Table 48. Prevalence of noise exposure of at least 85 dB (leq) in printing shops according to occupational health title.

Occupational health title group	Number of workers	Prevalence (%)	95 % confidence interval
1 Typesetting	28	4	0 - 18
2 Photographing, posting	31	-	0 - 11
3 Cutting	14	21	5 - 51
4 Printing	56	48	35 - 62
5 Binding	31	52	33 - 70
6 Others	11	18	2 - 52
Total	171	28	19 - 37

Differences (g-statistics): 2 vs 3: g=2.64, p<0.01
3 vs 4: g=1.80, p<0.10

EXPOSURE WITH HIGH SPECIFICITY ACCORDING TO TYPE OF INDUSTRY BUT RATHER LOW SPECIFICITY ACCORDING TO OCCUPATIONAL HEALTH TITLE GROUP

Exposure to offset chemicals (eg, hexavalent chromates), which are strong allergens and also carcinogens (33), may occur in the developing of printing plates. Of the workers (N = 171) 16 % (95 % confidence interval 11-22 %) were exposed (skin exposure, potential exposure of the respiratory tract) to hexavalent chromates. No such exposures were found in other types of industry (81). Therefore exposure to offset chemicals was highly specific according to type of industry.

Of the photographers and posters (N = 31), 26 % (95 % confidence interval 12-45 %) and, of the printers (N = 56), 30 % (95 % confidence interval 19-44 %) were exposed to hexavalent chromates (in offset chemicals). Both of these OHT groups differed highly significantly from the other workers, of whom (N = 84) only 2 % was exposed (<1-10 %) (g_{min} = 3.94, $p < 0.001$). However the specificity of hexavalent chromate exposure according to the OHT groups was rather low as the exposure commonly occurred in two of the five major OHT groups of the printing shops (table 47), the two of which comprised 51 % of the 171 workers in the printing shops.

EXPOSURE WITH LOW SPECIFICITY ACCORDING TO TYPE OF INDUSTRY BUT RATHER HIGH SPECIFICITY ACCORDING TO OCCUPATIONAL HEALTH TITLE GROUP

Of all the workers (N = 171) in the printing shops, 41 % (95 % confidence interval 33-49 %) were exposed to solvents. The exposure to solvents was common (over 10 % of the workers) in five of the eleven types of industry of the sample (81). Thus the specificity of solvent exposure according to type of industry was low.

Within the printing shops 21 % (95 % confidence interval 15-28 %) of the 171 workers also had their skin exposed for at least 15 min during the workday. The exposure prevailed among printers (N = 56), 55 % (95 % confidence interval 42-69%) of whom were exposed. Of all workers in the other occupational groups (N = 115), only 4 % (95 % confidence interval 1-10 %) were exposed. This difference between printers and other workers was highly significant ($g = 7.66$, $p < 0.001$). Therefore the specificity of solvent exposure was great for the printing shops according to OHT group.

EXPOSURE WITH HIGH SPECIFICITY ACCORDING TO BOTH TYPE OF INDUSTRY AND OCCUPATIONAL HEALTH TITLE GROUP

Developers and fixatives contain well-known allergens, eg, hydroquinones and aromatics which have an amino and a nitro group in the para position (56). Of the workers in the printing shops (N = 171) 5 % (95 % confidence interval 2-10 %) were exposed to hydroquinones. No such exposures were found in the other types of industry (81). Therefore exposure to hydroquinones had a high specificity according to type of industry.

The exposure to hydroquinones was prevalent among the OHTs of photographers and posters (N = 31), of which 23 % (95 % confidence interval 10-41 %) were exposed. Only 1 % (95 % confidence interval <1-5 %) of the 140 workers in the other OHTs were exposed. This difference between the groups was highly significant ($g = 4.76$, $p < 0.001$) and thus exposure to hydroquinones had a high specificity in printing shops also according to OHT group.

COMPARISON BETWEEN OFFSET PRINTERS AND RELIEF PRINTERS

Offset printing is an example of the breakthrough of a new technology during the past few decades. In small printing

shops this new technology is displacing that of relief printing. The aim of this part of the study was to describe the effects of this change on the chemical exposure and adverse effects on the skin of printers.

There were 31 offset printers and 21 relief printers in the 11 printing shops of the sample. All of the relief printers used small relief printing presses. The offset printing presses used were also small. Ten of the relief printers were women. All the other printers were men. The offset printers' mean age was 30 a, and the mean length of service in their present occupation 12 a. The corresponding figures for the relief printers were 41 and 18 a, respectively. The information on chemical exposure was obtained by means of the industrial hygiene survey (page 14), and that on adverse skin effects by means of a questionnaire (appendix VI).

Results

Solvents. The offset printers were more exposed to solvents than the relief printers. Of the offset printers (N = 31) 21 and of the relief printers (N = 21) 8 used solvents for washing by hand at least 15 min per workday without regular use of protective gloves ($g = 2.09$, $p < 0.05$). The offset printers used, at the time of the survey (1976), gasoline (exposure to benzene) more frequently than the relief printers. Of the offset printers (N = 31) 13 and of the relief printers (N = 21) 3 used gasoline daily for washing purposes ($g = 2.10$, $p < 0.05$).

Allergens. The offset printers were more exposed to allergens than the relief printers. Exposure to more than one allergen was typical of the offset printers. An offset printer had an average of 2.1 exposures and a relief printer 0.3 exposures to different allergens ($\chi^2_3 = 21.26$, $p < 0.001$). The difference between the two groups was also significant

according to the number of allergens ($\chi^2_2 = 9.40$, $p = 0.01$). The allergens of the offset printers were chromates (in offset chemicals), starch, and arabicum. Twelve offset printers (N=31) were exposed to three allergens. The only allergen of the relief printers (N=21) was starch, to which six workers were exposed.

Adverse skin effects. Adverse skin effects occurred more frequently among the offset printers than among the relief printers. Of the offset printers (N = 28) 18 and of the relief printers (N = 19) 6 workers reported adverse skin effects ($g = 2.18$, $p < 0.05$).

Discussion

Offset printers in particular may also have been exposed to allergens that were not taken into account in the survey. The information available for many of the chemicals used in offset printing was insufficient, leading to a probable systematic error in the results. The differences in chemical exposure between the offset printers and the relief printers is presumably even greater than that described in this study.

The offset printers used more solvents and also more toxic solvents than the relief printers. The cleansing of the rubber cylinder in the offset technique seems to require more solvents and more effective solvents than the cleansing of metal letters in relief printing. In addition the frequent change of colors in offset printing increases the amount of solvents needed.

The differences in the occurrence of adverse skin effects between the two occupational health titles were in accordance with the differences in chemical exposures.

However, it should not be overlooked that the change from relief printing to offset printing eliminates exposure to

inorganic lead in printing shops (71).

It can be concluded that the occupational change from relief printing to offset printing brings about a change in the profile of chemical exposure in small printing shops, and this tendency was shown by comparing two OHTs.

DISCUSSION

The results of part D of section IV of the study are summarized in fig 10. Any defined health hazard (or stress factor) within a given type of industry can in principle be classified into one of the four types of health hazards (A,B,C or D) according to the degree of specificity of its occurrence as compared to other types of industry and according to the degree of specificity of its occurrence within the industry in different OHTs or title groups of that industry.

Occupation	Type of industry: Low	Type of industry: High
Low	A (noise)	B (hexavalent chromate)
High	C (solvents)	D (hydroquinones)

Fig 10. A fourfold table classifying exposure with regard to the specificity of its occurrence according to type of industry and occupational health title.

The type D exposure generally prevails only in one OHT within one type of industry. Thus type D of an exposure entails the information required for the definition of a risk group.

With type C of an exposure the group at risk can only be defined within the type of industry in question. For the definition of risk groups in other types of industries, information is needed concerning the prevalence of the exposure according to OHTs in these industries.

A B-type risk group can only be defined according to type of industry. Within the type of industry the classification according to OHTs is of little value because the exposure is common in many OHTs within that industry.

Type A is common in many types of industry and many OHTs within a given type of industry. The classifications according to type of industry and OHTs are of little use for the definition of a risk group as fas as type A exposures are concerned. However it is unlikely that an exposure would be of type A in all types of industry and would thus be common in all types of industry and would be distributed fairly evenly in different OHTs within these industries. For example, although the exposure to a noise level of at least 85 dB (leq) was close to the A type of exposure in printing shops, it would have been a C type of exposure in the metal industry, because exposure to noise was very unevenly distributed in the OHTs of the metal industry (page 50).

SUMMARY

The results obtained by means of the fourfold table clarify the relationship between the classification according to type of industry and the classification according to OHTs.

At its best a prevalence figure based on OHTs can be used to estimate the size of the whole group at risk in the sampled population. On the other hand there are exposures in case of which classification according to OHTs does not bring about any substancial additional information as compared to the classification according to type of industry. The evaluation of the specificity of an exposure both according to type of industry and according to OHTs can be used as a systematic approach when groups at risk are defined on the basis of a sample.

V GENERAL DISCUSSION

The objective of this study was to survey the prevalence of health hazards and stress factors in small industry and to evaluate methods for the priorization of occupational health activities. Classifications according to type of industry and OHTs were part of a survey method which included the sampling of workplaces, the survey of health hazards and stress factors of each worker, and the use of indices to indicate the prevalence of health hazards and stress factors.

The survey method with all of its aforementioned components has not been used to the best of the author's knowledge in earlier studies, but parts of the method have been used in many surveys (53, 72, 74, 76, 81).

METHODOLOGY

Sampling method

The sampling technique employed was designed for a two-way stratification with small sample sizes. To increase the precision of the estimators, the sample had to be stratified according to type of industry because of the heterogeneity of the industry as a whole.

A three-digit system was selected as a basis for the breakdown of the classification according to type of industry (table 1), because random sampling from the strata which it defined allowed estimations concerning all types of small industry. Sufficiently large sample sizes from the main types of industry would, in addition, enable comparisons to be made between certain types of industry. However, on the basis of the stratification according to type of industry

used, it was not possible to estimate accurately the risk factors in the population with data obtained from relatively small types of industry.

The sample was also stratified according to the number of personnel at the workplace because the types of industry differed from each other with respect to the proportions of workers in the size categories (table 6). After the decision to choose a two-way stratification, the task was to find a sampling method which would allow estimations with two-way stratification, and in which the required sample size would be small. The admissible sample size (N = 100) had to be at least as large as the number of strata formed by an ordinary two-way stratification technique. In this case the table was made up of R "rows" corresponding to R=27 types of industry (when the negligible types of industry 314 and 361 were excluded) and C "columns" corresponding to the C=3 size of personnel categories; the result was a two-way table of RC=27·3=81 "strata cells." Since the population fractions falling into the 81 strata cells were known, these cells could have been used as the strata for sampling. In this case a sample at least as large as 81 would have been required. If variance estimation was desired, at least two workplaces would have been needed from each stratum, so that the sample would have had to be at least 2·RC=162. Such a sample may still not permit proportional allocation to the strata cells and hence may result in loss of precision for certain characteristics by comparison with a completely random design or a design employing a coarser system of strata.

In this study the sampling could not be carried out by starting from sampling fractions proportional to both type of industry and size of personnel, primarily because of two factors. First, because of the comprehensiveness of the survey of risk factors, the sample size (N = 100) could not be

increased because of limited financial resources (and the time) available. Second, had the sampling fractions based on type of industry and number of personnel been applied to establishments of varying sizes, many small workplaces in a small type of industry would have been left outside the sample or would have been underrepresented.

Bryant et al (9) have presented a sampling method which, for samples less than (twice) the number of strata, permits estimation in a two-way stratification. The method primarily permits estimation of the population mean. Furthermore, such estimates can be presented separately for types of industry (rows) and personnel size categories (columns). Finally, the method provides estimates of the variance of the estimated population mean. The only restrictions on sample size are that, for estimates of means, the sample must be larger than the larger of the two factors R and C, and, for estimates of variances, the sample must be at least twice the size of the larger of factors R and C.

It was decided to perform a two-way stratified sampling as shown in appendix III, when R=27 and C=3: with N=100, the aforementioned requirements for the sample size needed were thus met. With a sample size as small as this, an ordinary stratification device does not permit the estimation of sampling error.

Survey method

The survey method used was semiquantitative in nature. Most of the health hazards and stress factors surveyed were classified into rather crude ordered categories on the basis of measurements with directly readable instruments or observations.

The data for the evaluation of work conditions from the standpoint of health can be collected in many ways, and their nature may vary. If the effects of work conditions (eg, occupational diseases) are not taken into consideration the information concerning work conditions can be classified as follows on the basis of the method of data collection: import statistics, questionnaire on work conditions, a qualitative survey of health hazards (77), a semiquantitative survey of health hazards (81, 86) and quantitative survey of health hazards (36). In this order the health relevance of the data increases, but the cost of collection of the data also increases. Therefore the feasibility of a study with a wide scope (such as the present study) becomes smaller as health relevance increases.

In the NIOSH surveys chemical exposure was assessed on a qualitative level (nature and duration of exposure) (77). In a Swedish survey chemical factors were assessed quantitatively as well (74). The indicator tubes (Drâger) used in this survey were semiquantitative in nature (44) and were thus a compromise between the two other survey methods when quantitative accuracy and feasibility are used as criteria.

Therefore the realistic alternatives as far as the survey method was concerned were a qualitative survey (77) or a semiquantitative survey (86). A semiquantitative method was chosen because it increased the health relevance of the data without undue additional costs.

Health hazards and stress factors were surveyed for each worker separately according to the "risk model" (61). Therefore, the unit of the survey was an individual worker and not a machine, workplace, or phase of work, all of which have usually been used in earlier surveys (1, 74). The survey of health hazards and stress factors for each separate worker was based on an assessment of the structure of each worker's

work task (page 127, appendix IV). This approach is essential in all surveys in which an individual worker is the unit of the survey, except in biological monitoring or when the worker himself carries the measuring equipment through the workday (45). Using an individual worker as the unit of the assessment of exposure is not new in industrial hygiene or ergonomics, but it has not generally been used in previous surveys.

Health hazards and stress factors surveyed

To allow comparisons of different types of industry and different OHTs, the variety of health hazards and stress factors had to be surveyed. Therefore all types of health hazards and stress factors (physical, chemical and ergonomic factors) were included in the survey. However, those factors with a low prevalence (eg, ionizing radiation, ultrasound and biological factors) were not included in this report. In previous surveys based on type of industry, only physical and chemical factors were included (53, 74, 76).

Classification of health hazards and stress factors

Noise, illumination, chemical exposure, as measured by indicator tubes, and physical work load were classified into three or four classes according to an ordinal scale (page 15-18 and tables 4, 5 & 8 in appendix I). However, the prevalence of health hazards and stress factors is usually presented in only one class for both the sake of clarity and relevance to health.

Index of the standard of industrial hygiene

The directives used in the definition of risk exposures, the prevalence of which determined the standard of industrial hygiene, did not include every kind of risk exposure (19).

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Generally, in the index of the standard of industrial hygiene used, toxic effects of chemical substances (except carcinogenic effect) were emphasized. Sensitizing, carcinogenic and irritating effects have been given less attention in the directives that defined risk exposures. However, in the definition of risk exposures it was important to use criteria that were nationally accepted by various interest groups (19). The method for calculation of the standard of industrial hygiene (number of risk exposures per 100 workers) has been used in an earlier study (53). However the bias that results from the use of the Finnish limit values (FLVs) should not be overlooked (2, 63, 73, 87). Long-term toxic effects are probably underestimated in the FLVs (59). Also it should be emphasized that the noise level of 85 dB (leq) was used because of the risk of noise-induced hearing loss. Even a noise level of less than 80 dB (leq) may be a stress factor (6, 10, 41).

Collection and quality of the data

A uniform procedure in the collection of data was a prerequisite for the comparison of different groups of workers. The two phases of the survey (two visits to each workplace)(81, 85), the division of workers' work tasks into subtasks (81, 85), an adequate interview (18), use of the same persons in the same tasks throughout the survey, training of the surveyors before the survey, and detailed instructions for the survey of different health hazards and stress factors (77, 80, 81) made it possible to describe uniformly and to increase the representativity of the data about work conditions that may change with time. Furthermore, the specialists who surveyed the health hazards and stress factors had to be familiar with the production methods used, be well-trained in the use of the survey methods, and adopt a thorough way of working (60).

Before the field study phase the surveyors visited 15 industrial workplaces in order to gain experience and to clarify the tasks and collaboration between each member of the surveyor group. A pilot study was carried out in three workplaces with different production methods (manufacture of metal products, a printing shop and a bakery) in order to train the surveyors to survey health hazards and stress factors uniformly.

The surveyors visited each workplace twice. Each surveyor carried out the same tasks throughout the investigation. The physiotherapist surveyed ergonomic factors. The industrial hygienist and the author surveyed hygienic conditions. The authors' tasks in each workplace were to define each worker's work task and work areas and to define the average daily durations of exposures. After the survey it was the author's responsibility to see that the material was coded correctly and uniformly.

The workplaces of the same types of industry were surveyed successively. This procedure had two advantages. First, differences in climatic conditions had no substantial effect on the conditions within one type of industry (eg, metal industry workplaces were surveyed during the warm part of the year). Second, the procedure increased the uniformity of the survey and allowed the learning effect of the surveyors to be taken into account in all the workplaces of a given type of industry.

PREVALENCE OF HEALTH HAZARDS AND STRESS FACTORS IN SMALL INDUSTRY

Representativeness of the survey

During the choice of the sampling method (9), the aim was

to gain the highest accuracy possible in the estimates from the sample as a whole. The objective was also to obtain accurate information on the main types of industry to allow a comparison of these industries to be made (81).

The estimates concerning rather homogeneous groups of workplaces with respect to production methods and work conditions were accurate. Such types of industry included printing shops (N = 16) and bakeries (N = 9). The manufacture of wearing apparel (clothing) gave a somewhat less uniform group of workplaces, but on the basis of the number of workplaces (N = 9) the representativity of this type of industry can be considered fairly good.

However, in the manufacture of metal products and of machinery there was great variation in the production methods and products. The generalizations to the study population should not, therefore, be regarded as accurate. The heterogeneity of the work conditions in the manufacture of metal products and in that of machinery is reflected in the standard errors of the estimates. A large standard error does not as such, however, mean that the information was not representative. It describes the heterogeneity of the estimated parameter within the type of industry. As far as the representativeness is concerned, random sampling of the workplaces is of major importance. The prevalence of health hazards and stress factors (point estimates) in the manufacture of metal products and machinery can, therefore, be very accurate, although the degree of representativeness cannot be regarded as high (81).

Estimates concerning a type of industry have also been presented for industries which are represented in the sample by only three or four workplaces (tables 3 & 8-18, appendix I). In some of these industries the production methods and work conditions were fairly similar (eg, the manufacture of plastic products and the manufacture of wood products), and the estimates are thus assumed to be accurate. On the other hand,

the manufacture of other mineral products was represented by three workplaces using different production methods, and thus prevalences of this industry cannot be regarded as representative of the whole industry (81).

The structure of small industry according to type of industry in Uusimaa and the rest of Finland is different. Therefore estimates of the prevalences of health hazards and stress factors concerning the small industry in Uusimaa cannot be generalized to all small industry in Finland. The proportion of industries manufacturing food products and those types of industry directly using natural raw materials (wood, clay, leather) was greater in the rest of Finland than in Uusimaa in 1974. Correspondingly, the proportion of types of small industry with a relatively high degree of processing (printing industry, chemical industry and the metal industry) was greater in Uusimaa than in the rest of the country (81).

The prevalences concerning a particular type of industry can supposedly be generalized, at least approximately, to the whole country. There is no reason to assume that eg, bakeries, clothing factories, woodwork shops, printing shops, or metal workshops are substantially different from the same types of industry in other provinces or the whole country as far as work conditions are concerned (81).

Information about work conditions in 1976 may soon be out of date, perhaps in 5-10 a, as the structure of small industry according to type of industry supposedly continues to change fairly rapidly. However prevalences of health hazards concerning different types of industry are unlikely to become outdated in such a short period of time. New small industry workplaces will presumably use the same production methods as the older ones, and so typical labor protection problems will tend to recur (74).

Comparison with other studies

Small industry had not previously (before 1976) been studied in Finland from the point of view of labor protection. The work environment in small industry has, however been studied in Sweden (74). Many of the results from the present and the Swedish study were similar - eg, noise was a particular problem in industries processing wood and metal and poor illumination was common in the manufacture of clothing and wood products and in printing shops (74). However, accurate comparisons with the Swedish study cannot be made because the survey methods were different.

The conditions of hygiene in two municipalities were surveyed in Finland in 1977 with special reference to occupational health care (34, 72). The material consisted of 99 workplaces with 1,715 workers. The prevalence of exposures requiring periodic medical examinations was 37 per 100 employees. In this study the prevalence of risk exposures was somewhat greater, 53 per 100 workers. The difference is predominantly due to the fact that in the 1977 material the proportion of industrial workplaces was only 60 % (N = 99), and the majority of the other workplaces produced services, in which the prevalences of health hazards are much smaller than in industry. Therefore the prevalences of the two studies cannot be compared with any accuracy.

The standard of industrial hygiene has been evaluated in the United States on the basis of the prevalence of risk exposure (53, 76). The prevalences have been of the same magnitude (50-60 risk exposures per 100 workers) as in the present study. However, accurate comparisons are not possible because either the basic populations in the American studies also included workplaces other than industrial ones or the indicator was calculated without stratification according to the size of the workplace.

In the Chicago survey, the proportions of workers exposed to health hazards grew as the workplaces became smaller (76). The standard of industrial hygiene in small industry has also been considered lower than in industry as a whole by many international meetings discussing labor protection in small industry. On the other hand in the Swedish study (74), exposure to noise was less prevalent and work load caused by high temperature was smaller in small workplaces than in larger ones. Although the standard of industrial hygiene might be lower in small industry than in industry as a whole, this does not mean that occupation-related diseases should be more prevalent among employees in small industry. Almost one-half (42 %) of the workers in small industry had worked for less than 3 a in their present workplace (81).

To the best of the author's knowledge, there is very little scientific information about how the size of the workplace influences the prevalence of health hazards. The different workplace size groups to be compared should, as a minimum requirement for the study design, be similar with respect to their structure according to type of industry. Two factors should then be taken into account – First the influence of size of the workplace on the nature of the production methods used and second the influence of size of the workplace on the prevalence of health hazards when the same production methods are being used.

One must stress that occupational health surveys are needed for the assessment of prevalences of <u>current</u> occupational hazards, as it is difficult to draw conclusions about current occupational health problems on the basis of adverse health effects even if the proportion of undiagnosed occupational diseases would be small. This difficulty arises because those adverse health effects that have developed over a long period of time are often rather an index of occupational

health problems that have prevailed than an index of current occupational health problems (60, 78).

CLASSIFICATION ACCORDING TO TYPE OF INDUSTRY AND OCCUPATIONAL HEALTH TITLE IN THE ASSESSMENT OF RISK GROUPS

The classification according to type of industry proved to be applicable for the grouping of workplaces in clearly differing groups with respect to the prevalence of health hazards and stress factors (page 33). On the other hand, the classification according to OHTs within a given type of industry showed that the classification according to type of industry does not allow the formation of homogeneous groups of workers with respect to the prevalence of health hazards and stress factors (page 46). The classification according to OHTs is better than that according to type of industry for the formation of relatively homogeneous groups of workers with respect to the prevalence of risk factors.

The classifications may be used simultaneously for the definition of a group of workers exposed to a specific exposure (page 75). Within each type of industry a specific exposure can be classified into one of the four types (A,B,C or D) according to how characteristic the exposure is in a given type of industry as compared to other types of industry (the degree of specificity according to type of industry) and according to how characteristic the exposure is to the OHTs within the given type of industry (degree of specificity according to OHTs). In the presented systematics of defining the risk group, classifications according to type of industry and according to OHTs are part of a methodology including an efficient sampling of workplaces and an economic survey of health hazards and stress factors.

The classification according to OHTs may also be used within a firm to survey a risk group with respect to a specific exposure. Then, compared with the systematics

presented on page 75, the firm would correspond to industry as a whole and the different workplaces or departments of the firm would correspond to different types of industry.

Different types of small industry were classified into three clearly differing groups on the basis of the standard of industrial hygiene (page 33). It should be noted that all the major types of industry of the study population were represented in the sample. Therefore the differences noted in the standard of industrial hygiene between different types of industry were not due to biased selection in sampling. The relevance of the classification according to type of industry was also shown in the comparison of the prevalence of health hazards and stress factors in the manufacture of metal products (SIC 381) and in the manufacture of machinery (SIC 382). The great majority of the health hazards and stress factors surveyed were more prevalent in the manufacture of metal products than in the manufacture of machinery (page 48).

It can be generalized that the standard industrial classification (75) enables the allocation of resources according to the needs of small industry in occupational health care. For example, occupational health services covering all employees in Finland were first carried out, according to legislation of 1978, in the types of industry with the most severe occupational health problems (20, 84). Industrial hygiene surveys using the standard industrial classification in the priorization of occupational health activities have also been made in many other countries (53, 74, 76).

It has generally been thought that, when the classification according to type of industry is continued deeply enough, one can refer to type of occupation or occupation. This kind of approach has been promoted by the offical classification of occupations (23, 35), in which (as in the classification

according to type of industry) criteria of importance to occupational health have gained too little emphasis (page 20). However it is to be stressed that classification according to type of industry and classification according to occupational health titles have different kinds of criteria (type of product - type of production method), and thus the corresponding classifications are naturally different. Therefore, OHTs can also be used to homogenize the prevalence of risk factors within a type of industry in situations where a continued classification according to type of industry is useless with respect to the homogenization of the prevalence of risk factors (page 46). The classification according to OHTs was better than the classification according to type of industry, as there existed OHTs characteristic to the compared types of industry. Information that could be obtained with a classification according to OHTs was lost in the classification of the same OHTs in the two types of industry.

The fact that classification according to OHTs is better than that according to type of industry also shows that the main criterion for OHTs, the production method, is more valid with respect to occupational health than the main criterion of type of industry, the nature of the product.

The classifications according to type of industry and occupational titles have often been used in occupational health (30, 31, 50, 53, 65, 74, 76, 81, 82), but to the best of the author's knowledge they have not previously been compared. The relationship between the two classifications has therefore been unclear.

CLASSIFICATION ACCORDING TO OCCUPATIONAL HEALTH TITLES

The grouping of workers under occupational health titles was based on the assumption that differences between groups of workers (as far as the prevalences of risk factors are concerned) are to a great extent due to the differences in

the production methods used by the groups of workers. Otherwise it would have been difficult to understand the great differences between different types of industry observed in earlier studies (53, 74, 76, 81). The assumption about the importance of the production method used was also supported by the accumulation of risk factors at the beginning of the production process in different types of metal industry (81) and in large companies within the metal industry (52). An obvious reason for this accumulation was the differences in production methods at the beginning and end of the production process. In addition it should be mentioned that Gamble & Spirtas (26) have, with promising results, used occupational titles defined according to the production process in their description of chemical exposure.

The relationship between physical work environment factors (eg, noise, radiation) and the work task and the production method used may be evident. It is also clear that passive exposure (85), which is caused by another worker's work, diminishes the discriminating power of a classification based on the production method used. However, passive exposure does not necessarily diminish the homogeneity of an OHT with respect to a specific exposure because the production method used may determine the worker's place in the production process and in this way it may indirectly homogenize even passive exposure.

Some production methods always involve specific exposures (eg, welding). A chemical exposure may in practice be specific to a production method or a production process (eg, exposure to carbon disulfide in a viscose process). However, the relationship between production method and chemical exposure is generally not evident because the same production method may involve different exposures, depending on the raw materials used. Exposure to chromium and nickel was more prevalent in the manufacture of machinery than in the manufacture of metal products (page 48) because of the more

common processing of stainless steel in the manufacture of machinery.

The relationship between ergonomic factors and the work task and the production method was assumed to be due to the fact that the work task and the production method influence the physical dimensions of an individual workplace and also the work content, which affect the physical and mental work load associated with work (80, 85).

It was not assumed that the work task and the production method would homogenize all kinds of health hazards and stress factors and that with it homogeneous groups of workers could be formed with regard to a specific exposure, or, more broadly, work load. The work task and the production method was used as the major criterion in classifying workers under different OHTs because it was a simple enough criterion and it was assumed that health hazards and stress factors could be considerably better homogenized in groups of workers than by using type of industry (which is mainly based on the nature of the product) as a criterion for classification.

OCCUPATIONAL HEALTH TITLES AND EPIDEMIOLOGIC SURVEYS

It is proposed that the method of using "old" OHT reference groups for newer OHTs brought about by technological development provides the basis for a useful study design for two purposes.

First, this method can be used for the description of changes in exposures or, more broadly, work loads associated with new production methods. The occupational change from relief printing to offset printing increased the prevalence of chemical exposure (page 65). The offset printer OHT is growing and relief printers are correspondingly on the decline.

Second, the defined study design may be applicable in epidemiologic surveys when the effects of combinations of different work loads are to be studied because OHTs can be selected to represent different degrees of the same combination of exposures or work loads and to homogenize occupational factors other than those being studied, to homogenize extra occupational factors and factors related to the workers themselves.

ANTICIPATION OF CHANGES IN THE PREVALENCE OF HEALTH HAZARDS AND STRESS FACTORS

The hygienic conditions in small industry will clearly change if there is a major change in any of the three groups of industries representing different standards of industrial hygiene (page 33). Some conclusions can also be drawn about the effect of possible structural changes within the small metal industry on the prevalence of occupational health problems. If the relative proportions of the manufacture of electrical apparatus (SIC 383) and the manufacture of machinery (SIC 382) grow and the proportion of the manufacture of metal products (SIC 381) correspondingly declines, the hygienic conditions will improve and the manual work load will diminish in the small metal industry. Naturally, new chemicals produced as a result of technological changes may have an opposite effect on hygienic conditions.

Most of the differences in the prevalence of the health hazards and stress factors surveyed between the manufacture of metal products and the manufacture of machinery (page 48) were related to their different occupational structures (different proportions of the same OHT groups)(page 49).

Occupational structure based on OHTs could, in principle, be used to explain the differences in the prevalence of occupational health problems between any two groups of

workplaces where the same production methods are used but in different proportions.

This conclusion leads to the idea of using occupational structures as defined in this study for the anticipation of changes in work conditions in one given group of workers because changes in occupational health problems, as far as work conditions are concerned, are presumably to a considerable extent due to changes in the proportions of different production methods as new ones replace old ones.

Therefore the structural unit affecting the prevalence of occupational health problems may also be occupational structure (page 23), either within a type of industry (page 49) or within a firm. A change in the structure of OHTs means that occupational titles covering older kinds of production methods (eg, relief printers) will be substituted by occupational titles covering new production methods (eg, offset printers).

However, new OHTs may change the work conditions of older OHTs through passive exposure, and thus information concerning the prevalence of the health hazards of older OHTs may become inaccurate in the process of changes in occupational structure.

The need to anticipate changes in work conditions and, at the same time, the importance of industrial and occupational structures is increasing because of rapid technological development.

In previous studies changes in occupational structures have been related to changes in the nature of work (29), but health hazards and stress factors have gained little attention.

VI CONCLUSIONS

1. The methodology, which included sampling of workplaces, the survey of hygienic and ergonomic factors of each worker, indices on the prevalence of occupational health problems, the classification of workplaces according to type of industry, and the classification of workers according to OHTs is applicable to the survey of work conditions for the prioriza-tion of occupational health activities and for the anticipa-tion of changes in the prevalence of occupational health problems.

2. Both categories used for the classification of workers, type of industry and OHT, proved to be useful for occupational health purposes because health hazards and stress factors were unevenly distributed within both of them. However classification according to OHTs is better if more accurate information is to be obtained than that gained on the prevalence of health hazards and stress factors by classifi-cation according to type of industry.

3. Most of the observed differences in the prevalence of risk factors between the two types of metal industry were related to their occupational structures. Changes in occupational structures can be used to anticipate changes in the prevalence of health hazards and stress factors. The concept of occupational structure has growing importance in occupational health because of rapid technological changes.

4. Occupational health titles are very suitable for the study of the influence of technical progress on work conditions and health.

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APPENDIX I

TABLES REFERRED TO, BUT NOT INCLUDED, IN THE TEXT

Table 1. Small industrial workplaces in the province of Uusimaa classified according to type of industry and the number of personnel in 1972. The figures are proportions of the total number of workplaces and the number of personnel (in parentheses).[a] (Source: The Register of Enterprises)

Type of industry (SIC)		Number of personnel 5-9	10-19	20-49	Total 5-49
311	manufacture of food products	.0238 (221)	.0356 (704)	.0378 (1639)	.0972
312	food manufacture	.0033 (33)	.0014 (24)	.0056 (242)	.0105
313	beverage industries	.0014 (17)	.0007 (11)	.0021 (94)	.0042
321	manufacture of textiles	.0133 (133)	.0126 (249)	.0146 (688)	.0405
322	manufacture of wearing apparel	.0315 (282)	.0371 (694)	.0209 (916)	.0895
323	manufacture of leather and products of leather	.0056 (55)	.0014 (30)	.0007 (45)	.0077
324	manufacture of footwear	.0007 (7)	.0007 (19)	.0021 (91)	.0035
331	manufacture of wood and wood products	.0237 (221)	.0189 (378)	.0091 (406)	.0517
332	manufacture of furniture	.0133 (121)	.0084 (153)	.0091 (444)	.0308
341	manufacture of paper and paper products	.0042 (40)	.0049 (89)	.0042 (154)	.0133
342	printing industry	.0720 (667)	.0601 (1147)	.0420 (1877)	.1741
351	manufacture of industrial chemicals	.0056 (53)	.0035 (63)	.0028 (93)	.0119

Type of industry (SIC)		Number of personnel			Total
		5-9	10-19	20-49	5-49
352	manufacture of other chemical products	.0182 (170)	.0154 (336)	.0153 (713)	.0489
353	petroleum refineries	.0014 (13)	.007 (10)	0 (0)	.0021
354	micellaneous products of petroleum and coal	.0007 (6)	.0007 (11)	.0014 (57)	.0028
355	manufacture of rubber products	.0014	.0021	.0007	.0042
356	manufacture of plastic products	.0140 (125)	.0105 (196)	.0119 (527)	.0364
362	manufacture of glass and glass products	.0042 (39)	.0021 (43)	.0021 (71)	.0084
369	manufacture of other non-metallic mineral products	.0112 (114)	.0098 (205)	.0084 (449)	.0294
371	iron and steel basic industries	.0014 (14)	.0007 (18)	.0035 (201)	.0056
372	nonferrous metal basic industries	.0035 (32)	.0014 (25)	.0028 (119)	.0077
381	manufacture of fabricated metal products	.0496 (481)	.0406 (806)	.0259 (1062)	.1161
382	manufacture of machinery	.0280 (272)	.0196 (397)	.0321 (1440)	.0797
383	manufacture of electrical apparatus	.0189 (185)	.0160 (310)	.0133 (550)	.0482
384	manufacture of transport equipment	.0084 (75)	.0084 (159)	.0084 (344)	.0252
385	manufacture of professional and scientific equipment	.0056 (56)	.0042 (84)	.0049 (211)	.0147
390	other manufacturing industries	.0168 (153)	.0091 (170)	.0098 (444)	.0357

Type of industry (SIC)	Number of personnel			Total
	5-9	10-19	20-49	5-49
Total, proportions	.3819	.3266	.2915	1.0000 (N= 1430)
Total (number of personnel)	(3,601)	(6,375)	(12,917)	(22,893)

a) Industries 314 (tobacco manufacture) and 361 (manufacture of pottery) were not included because their proportions were less than 1 o/oo in the above categories according to the number of personnel.

Table 2. The sample. (WP = workplaces, P = personnel, PS = personnel surveyed)

Type of industry (SIC)[a]	Numner of personnel											
	5 - 9			10 - 19			20 - 49			Total		
	WP	P	PS	WP	P	PS	WP	P	PS	WP	P	PS
311	2	16	15	5	69	56	3	66	40	10	151	111
312 - 313	1	10	10	-	-	-	-	-	-	1	10	10
321	2	15	12	2	27	24	-	-	-	4	42	36
322	2	20	19	3	40	33	4	138	116	9	198	168
323 - 324	-	-	-	-	-	-	1	40	33	1	40	33
331	1	5	5	2	21	22	1	27	24	4	53	51
332	1	6	5	2	17	16	1	32	24	4	55	45
341	1	3	4	-	-	-	-	-	-	1	3	4
342	7	34	36	4	54	37	7	188	135	18	276	208
351	-	-	-	-	-	-	-	-	-	-	-	-
352	4	27	11	1	12	6	1	43	23	6	82	40
353 - 355	-	-	-	1	25	12	-	-	-	1	25	12
356	2	12	13	1	20	13	1	50	43	4	82	69
362	-	-	-	1	8	5	-	-	-	1	8	5
369	2	13	10	1	19	6	-	-	-	3	32	16
371 - 372	1	6	5	-	-	-	-	-	-	1	6	5
381	6	44	40	4	47	39	5	115	85	15	206	164
382	2	15	10	3	52	30	1	42	36	6	109	76
383	2	20	9	2	23	23	1	22	20	5	65	52
384	-	-	-	-	-	-	1	16	11	1	16	11
385	1	10	10	-	-	-	-	-	-	1	10	10
390	1	5	4	1	18	10	2	55	41	4	78	55
Total	38	261	218	33	452	332	29	834	631	100	1547	1181

[a] See table 1 for a description of the types of industry.

Table 3. Number of workplaces, personnel and production workers in the sample according to type of industry.

Type of industry (SIC)		Work-places	Person-nel	Production workers	
				N	% of personnel
3	industry	100	1547	1181	76
311	manufacture of food products	10	151	111	74
	31179 other manufacture of bakery products	9	134	106	79
321	manufacture of textiles	4	42	36	86
322	manufacture of wearing apparel	9	198	168	85
331	manufacture of wood and wood products	4	53	51	96
332	manufacture of furniture	4	55	45	82
342	printing industry	18	276	208	75
	342011-13 relief and litho-graphic printing	16	226	171	76
352	manufacture of other chemical products	6	82	40	49
356	manufacture of plastic products	4	82	69	84
369	manufacture of other non-metallic mineral products	3	32	16	50
38	manufacture of metal products, machinery and electrical apparatus	26	380	292	77
	381 manufacture of metal products	15	206	164	80
	382 manufacture of machinery	6	109	76	70
	383 manufacture of electrical apparatus	5	65	52	80
other industries (312-313, 323-324, 341, 353-355, 362, 371-372, 384-385 and 390)		12	196	145	74

Table 4. Classification of chemical exposures according to the Finnish exposure limit values (FLV_{8h}) (21).

Magnitude of exposure		Index of exposure according to the toxicity of the chemical [a]			
		I	II	III	IV
No exposure	Exposure not detectable	0	0	0	0
Small exposure	$<0.5 \times FLV_{8h}$	1	1	1	1
Exposure approximately = FLV	$0.5-<1.5 \times FLV_{8h}$	3	2	2	2
Exposure greater than FLV	$\geq 1.5 \times FLV_{8h}$	4	4	3	2

[a] The toxicity of the substance (I-IV) was classified in the list of common industrial chemicals (36).

Table 5. Classification of chemical exposures according to the Finnish exposure limit values (FLV_{15min}) (21).

Magnitude of exposure		Index of exposure according to the toxicity of the chemical [a]			
		I	II	III	IV
No exposures	Exposure not detectable	0	0	0	0
Small exposure	$<0.5 \times FLV_{15min}$	0	0	0	0
Exposure approximately = FLV	$0.5-<2 \times FLV_{15min}$	2	2	1	1
Exposure greater than FLV	$\geq 2 \times FLV_{15min}$	3	3	2	2

[a] See note to table 4.

Table 8. Exposure of workers to noise according to type of industry.

Type of industry	Noise level (leq)							
	≥ 80dB		≥ 85 dB		≥ 90 dB		≥ 100 dB	
	Workers (%)	SE[a]	Workers (%)	SE[a]	Workers (%)	SE[a]	Workers (%)	SE[a]
SMALL INDUSTRY	50.0	3.2	32.1	2.9	16.5	2.3	2.6	1.1
Manufacture of food products	13.9	8.2	9.9	8.2	9.9	8.2	-	.
Other manufacture of bakery products	6.7	5.5	-	.	-	.	-	.
Manufacture of textiles	34.4	28.3	19.6	18.1	4.3	2.0	-	.
Manufacture of wearing apparel	12.3	4.5	2.4	2.9	2.4	2.9	-	.
Manufacture of wood and wood products	77.0	14.6	76.4	14.6	59.8	8.5	5.8	3.5
Manufacture of furniture	96.9	3.5	81.6	9.7	66.4	11.1	13.5	13.9
Printing industries	59.3	3.0	28.4	4.0	6.1	1.4	0.2	0.3
Relief and lithographic printing	59.5	3.4	28.3	4.5	6.4	2.1	0.3	1.2
Manufacture of other chemical products	66.5	16.1	10.8	6.3	2.9	2.8	-	.
Manufacture of plastic products	58.1	10.4	29.0	19.4	18.4	14.6	3.3	3.7
Manufacture of other non-metallic mineral products	55.6	34.1	55.6	34.1	27.7	28.4	11.0	11.4

Manufacture of metal products	68.5	6.8	58.6	7.4	36.8	7.4	10.1	6.4
Manufacture of machinery	43.7	16.1	24.6	8.8	15.2	10.3	0.7	0.4
Manufacture of electrical apparatus	40.8	19.2	24.1	13.3	10.3	9.6	-	.

[a]Standard error = SE

Table 9. Exposure of workers to vibration of the upper extremities according to type of industry.

Type of industry	Workers (%)	Standard error
SMALL INDUSTRY	10.9	1.6
Manufacture of food products	-	.
Other manufacture of bakery products	-	.
Manufacture of textiles	-	.
Manufacture of wearing apparel	-	.
Manufacture of wood and wood products	5.3	3.0
Manufacture of furniture	11.3	4.9
Printing industries	1.2	1.3
Relief and litho-graphic printing	1.2	1.2
Manufacture of other chemical products	1.5	1.4
Manufacture of plastic products	-	.
Manufacture of other non-metallic mineral products	5.6	5.7
Manufacture of metal products, machinery and electrical apparatus	26.8	..
Manufacture of metal products	32.0	7.0
Manufacture of machinery	18.2	11.7
Manufacture of electrical apparatus	16.4	9.6

Table 10. Illumination according to type of industry.

Type of industry	Poor illumination		Poor or moderately poor illumination		Influence of daylight	
	Workers (%)	SE[a]	Workers (%)	SE[a]	Workers (%)	SE[a]
SMALL INDUSTRY	19.6	2.3	42.6	3.0	18	
Manufacture of food products	19.6	7.7	50.1	9.4	46	
Other manufacture of bakery products	23.7	8.7	49.3	11.9	49	
Manufacture of textiles	2.2	2.0	22.5	8.1	44	
Manufacture of wearing apparel	2.2	1.7	8.3	2.6	33	
Manufacture of wood and wood products	16.4	9.7	30.0	10.4	8	
Manufacture of furniture	7.3	6.9	34.5	17.3	33	
Printing industries	20.5	3.9	53.3	6.5	6	
Relief and lithographic printing	16.4	4.8	47.4	6.9	13	
Manufacture of other chemical products	18.4	16.1	70.7	12.1	-	
Manufacture of plastic products	1.7	1.9	41.9	16.4	4	
Manufacture of other non-metallic mineral products	72.1	28.4	72.1	28.4	-	
Manufacture of metal products, machinery and electrical apparatus	26.2	..	42.7	..	12	
Manufacture of metal products	39.6	7.4	58.0	6.9	14	
Manufacture of machinery	7.8	4.9	27.8	13.2	11	
Manufacture of electrical apparatus	19.4	9.6	22.9	9.6	4	

[a] SE = standard error.

Table 11. Exposure of workers to ultraviolet radiation according to type of industry.

Type of industry	Workers (%)	Standard error
SMALL INDUSTRY	6.8	1.4
Manufacture of food products	-	.
Other manufacture of bakery products	-	.
Manufacture of textiles	-	.
Manufacture of wearing apparel	-	.
Manufacture of wood and wood products	0.6	1.0
Manufacture of furniture	-	.
Printing industries	8.1	2.6
Relief and litho-graphic printing	8.0	2.9
Manufacture of other chemical products	1.5	1.4
Manufacture of plastic products	-	.
Manufacture of other non-metallic mineral products	-	.
Manufacture of metal products, machinery and electrical apparatus	20.5	..
Manufacture of metal products	29.2	7.0
Manufacture of machinery	8.6	2.9
Manufacture of electrical apparatus	14.2	9.6

Table 12. Chemical risk exposures according to type of industry. The prevalence of risk exposures is presented as an index (number of risk exposures per 100 workers). Exposures were evaluated according to the Finnish exposure limit value (FLV) for both 8 h (FLV_{8h}) and 15 min (FLV_{15min}). The magnitude of exposure (2 or 3) in in parentheses. (See tables 4 & 5).

Type of industry	Risk exposure FLV_{8h} (≥ 2)		Risk exposure FLV_{15min} (2)		Risk exposure FLV_{15min} (3)	
	Index	Standard error	Index	Standard error	Index	Standard error
SMALL INDUSTRY	2.8	1.5	6.0	1.8	1.3	0.7
Manufacture of food products	-	.	-	.	-	.
Other manufacture of bakery products	-	.	-	.	-	.
Manufacture of textiles	-	.	8.0	8.1	-	.
Manufacture of wearing apparel	-	.	2.2	1.7	-	.
Manufacture of wood and wood products	-	.	-	.	2.0	1.7
Manufacture of furniture	12.4	13.9	35.2	24.3	6.2	6.9
Printing industries	-	.	-	.	1.4	1.9
Relief and litho-graphic printing	-	.	-	.	-	.
Manufacture of other chemical products	6.3	3.2	36.8	16.1	0.7	0.7
Manufacture of plastic products	-	.	1.3	1.1	10.1	9.7
Manufacture of other non-metallic mineral products	-	.	-	.	-	.
Manufacture of metal products, machinery and electrical apparatus	8.3	..	8.8	..	1.4	..
Manufacture of metal products	13.6	9.3	10.7	9.3	2.8	2.8
Manufacture of machinery	-	.	0.7	0	-	.
Manufacture of electrical apparatus	-	.	8.0	7.7	-	.

Table 13. Exposure of workers to allergens according to type of industry.

Type of industry	Workers (N)	Exposure according to number of allergens			Allergens x 100 workers	Exposures that could not be evaluated/workers x 100
		1	2	3		
SMALL INDUSTRY	1,181	38.1	6.5	1.6	56	12
Manufacture of food products	111	95	-	-	95	12
Manufacture of textiles	36	55	3	-	61	8
Manufacture of wearing apparel	168	87	10	-	107	7
Manufacture of wood and wood products	51	42	-	-	42	2
Manufacture of furniture	45	62	20	-	102	-
Printing industries	208	13	8	-	29	29
Manufacture of other chemical products	40	10	-	-	10	63
Manufacture of plastic products	69	39	28	23	164	50
Manufacture of other non-metallic mineral products	16	50	13	-	75	38
Manufacture of metal products, machinery and electrical apparatus	313	20	4	1	30	9
Manufacture of metal products	164	9	1	2	15	10

Manufacture of machinery	76	32	7	-	46	1
Manufacture of electrical apparatus	52	44	10	-	63	25

Table 14. Exposure of workers to carcinogens according to type of industry.

Type of industry	Workers (N)	Exposure according to the number of carcinogens			Carcinogens x 100 workers	Exposures that could not be evaluated/workers x 100
		1	2	3		
SMALL INDUSTRY	1,181	16	4.3	1.5	29	9
Manufacture of textiles	36	56	-	-	6	11
Manufacture of wearing apparel	168	17	-	-	17	7
Manufacture of wood and wood products	51	27	-	-	27	2
Printing industries	208	26	6	-	37	8
Manufacture of other chemical products	40	8	-	-	8	56
Manufacture of plastic products	39	3	23	23	119	3
Manufacture of metal products	164	15	2	1	21	3
Manufacture of machinery	76	12	24	1	60	5
Manufacture of electrical apparatus	52	38	4	-	46	-

Table 15. Prevalence of risk exposures according to type of industry (number of risk exposures per 100 workers).

Type of industry	Risk exposure[a]		Uncertain risk exposure[a]	
SMALL INDUSTRY	53.0	(4.5)	19.7	(2.3)
Manufacture of food products	11.9	(8.2)	-	(.)
Other manufacture of bakery products	3.0	(2.0)	-	(.)
Manufacture of textiles	29.7	(20.2)	22.5	(6.1)
Manufacture of wearing apparel	6.2	(2.9)	5.8	(4.3)
Manufacture of wood and wood products	75.9	(16.3)	6.9	(6.1)
Manufacture of furniture	98.7	(20.1)	35.8	(24.3)
Printing industries	34.7	(5.0)	24.0	(3.1)
Relief and lithographic printing	32.0	(4.1)	26.3	(3.7)
Manufacture of other chemical products	52.2	(32.2)	1.5	(1.4)
Manufacture of plastic products	44.5	(24.3)	63.2	(19.4)
Manufacture of other non-metallic mineral products	166.7	(73.9)	33.2	(34.1)
Manufacture of metal products, machinery and electrical apparatus	78.8	(..)	24.7	(..)
Manufacture of metal products	95.4	(15.8)	31.7	(8.5)
Manufacture of machinery	62.9	(21.2)	10.9	(6.9)
Manufacture of electrical apparatus	53.2	(18.3)	16.0	(9.6)

[a]Standard error in parentheses.

Table 16. Index of risk exposures (number of risk exposures per a hundred workers) according to the type of industry.

Type of industry	Workers		Index	SE[a]
	N	Exposed (%)		
SMALL INDUSTRY	1,181	40.0	53.0	4.5
Manufacture of furniture (SIC 332)	45	85.8	97.7	20.1
Manufacture of metal products, machinery and equipment (SIC 38)	313	57.5	78.8	..
Manufacture of wood and wood products (SIC 331)	51	72.0	75.9	16.3
Manufacture of chemical products (SIC 352)	40	30.1	52.2	32.2
Manufacture of plastic products (SIC 356)	69	35.5	44.5	24.3
Printing industries (SIC 342)	208	33.8	34.7	5.0
Food manufacture (SIC 311)	111	11.9	11.9	8.2
Manufacture of wearing apparel (SIC 322)	168	6.2	6.2	2.9
Manufacture of textiles (SIC 321)	36	27.6	29.7	20.2
Manufacture of nonmetallic mineral products (SIC 369)	16	77.8	166.7	73.9

[a]SE = standard error.

Table 17. Heavy physical work load according to type of industry.

Type of industry	Physically heavy work		Systematic error[a]
	Workers (%)	Standard error	
SMALL INDUSTRY	26.9	2.6	15
Manufacture of food products	70.8	2.4	1
Other manufacture of bakery products	72.3	2.7	1
Manufacture of textiles	33.7	20.2	3
Manufacture of wearing apparel	5.7	3.0	11
Manufacture of wood and wood products	58.8	22.6	23
Manufacture of furniture	22.7	16.2	44
Printing industries	12.4	2.6	14
Relief and litho-graphic printing	13.1	2.9	9
Manufacture of other chemical products	41.7	16.1	22
Manufacture of plastic products	15.8	11.2	1
Manufacture of other non-metallic mineral products	44.4	34.1	13
Manufacture of metal products, machinery and electrical apparatus	21.1	..	24
Manufacture of metal products	30.8	7.4	32
Manufacture of machinery	8.2	3.1	20
Manufacture of electrical apparatus	1.9	1.9	12

[a]Moderately heavy work *or* heavy work was always classified into moderately heavy.

Table 18. Heavy static work load according to type of industry.

Type of industry	Heavy static work load		Systematic error[a]	No evaluation
	Workers (%)	Standard error		
SMALL INDUSTRY	32.2	2.7	18	12
Manufacture of food products	32.6	5.1	40	3
Other manufacture of bakery products	30.7	5.0	40	3
Manufacture of textiles	39.5	20.2	8	0
Manufacture of wearing apparel	69.0	8.4	7	1
Manufacture of wood and wood products	42.7	8.2	31	16
Manufacture of furniture	8.2	4.9	51	29
Printing industries	19.7	3.8	10	16
Relief and litho-graphic printing	18.2	4.6	9	19
Manufacture of other chemical products	32.7	16.1	10	2
Manufacture of plastic products	10.4	9.0	0	39
Manufacture of other non-metallic mineral products	33.2	34.1	13	38
Manufacture of metal products, machinery and electrical apparatus	26.3	..	23	10
Manufacture of metal products	27.0	6.5	18	11
Manufacture of machinery	16.8	5.8	43	8
Manufacture of electrical apparatus	31.5	11.5	12	10

[a]Moderately heavy *or* heavy static work load was always classified into moderately heavy.

Table 19. The need, availability and use of personal protective devices according to type of industry. (Index = number of protective devices per 100 workers)

Type of industry	Index			
	Need	Not available	Available	
			Not used	Used
SMALL INDUSTRY	97	47	23	27
Manufacture of food products	20	12	-	8
Other manufacture of bakery products	17	9	-	8
Manufacture of textiles	64	50	6	8
Manufacture of wearing apparel	19	17	1	1
Manufacture of wood and wood products	97	18	22	57
Manufacture of furniture	124	53	22	49
Printing industries	113	55	49	9
Relief and litho-graphic printing	117	60	46	11
Manufacture of other chemical products	129	78	33	18
Manufacture of plastic products	56	7	33	16
Manufacture of other non-metallic mineral products	125	75	44	6
Manufacture of metal products, machinery and electrical apparatus	175	86	34	55
Manufacture of metal products	179	74	40	65
Manufacture of machinery	158	53	43	62
Manufacture of electrical apparatus	91	54	8	29

Table 20. Classification of different types of industry according to their standard of industrial hygiene as measured by the index of risk exposures (number of risk exposures per 100 workers).

Type of industry	Workers		Standard error	Index
	N	Exposed (%)		
1. Manufacture of wood and furniture (SIC 33) and manufacture of metal products, of machinery and of electrical apparatus (SIC 38)	409	62.6	2.4	80.7
2. Manufacture of chemical products (SIC 35) and printing industries (SIC 342)	317	33.4	2.7	39.1
3. Manufacture of food products (SIC 311) and manufacture of wearing apparel (SIC 322)	279	8.2	1.6	8.2

Table 21. Classification of different types of metal industry according to their standard of industrial hygiene as measured by the index of risk exposures (number of risk exposures per 100 workers).

Type of industry	Workers		Index	Standard error
	N	Exposed (%)		
Manufacture of metal products (SIC 381)	164	65.9	95.4	15.8
Manufacture of machinery (SIC 382)	76	43.7	62.9	21.2
Manufacture of electrical apparatus (SIC 383)	52	49.3	53.2	18.3

Table 22. Classification of different types of metal industry according to the index of physical work load.

Type of industry	N	Index (great)		Workers (%) not classified
		Workers (%)	Standard error	
Manufacture of metal products (SIC 381)	164	61.8	6.1	30
Manufacture of machinery (SIC 382)	76	55.1	16.1	28
Manufacture of electrical apparatus (SIC 383)	52	46.5	8.0	31

Table 23. Classification of different types of metal industry according to the prevalence of high dynamic work load.

Type of industry	N	Dynamic work load high Prevalence (%)	SE[a]	System error[b]
Manufacture of metal products (SIC 381)	164	30.8	7.4	32
Manufacture of machinery (SIC 382)	76	8.2	3.1	20
Manufacture of electrical apparatus (SIC 383)	52	1.9	1.9	12

[a] SE = standard error.

[b] Moderately heavy *or* heavy work was always classified as moderately heavy; system = systematic.

Table 24. Classification of different types of metal industry according to the prevalence of high static work load.

Type of industry	N	Static work load high Prevalence (%)	SE[a]	System error[b]	Workers (%) not classified
Manufacture of metal products (SIC 381)	164	27.0	6.5	18	11
Manufacture of machinery (SIC 382)	76	16.8	5.8	43	8
Manufacture of electrical apparatus (SIC 383)	52	31.5	11.5	12	10

[a] SE = standard error.

[b] See note to table 23; system = systematic.

Table 27. Index of risk exposures (number of risk exposures per 100 workers) in the manufacture of metal products and machinery (SIC 381-382) according to types of industry (SIC) and occupational health title (OHT).

Group of workers	N	Index	Range within the group of workers
SIC 381-382	240	85	32 - 164
SIC 381	164	95	33 - 161
SIC 382	76	63	27 - 200
OHT 1-3	136	131	105 - 164
OHT 4-6	104	42	32 - 72

Table 28. Prevalence of heavy dynamic work in the manufacture of metal products and machinery (SIC 381-382) according to types of industry (SIC) and occupational health title (OHT).

Group of workers	N	Prevalence (%)	Range within the group of workers
SIC 381-382	240	24	3 - 59
SIC 381	164	31	0 - 60
SIC 382	76	8	0 - 50
OHT 1-2	96	36	35 - 37
OHT 3-4	71	4	3 - 5
OHT 5-6	73	40	31 - 59

Table 29. Prevalence of lead exposure in the manufacture of metal products and machinery (SIC 381-382) according to types of industry (SIC) and occupational health title (OHT).

Group of workers	N	Prevalence (%)	Range within the group of workers
SIC 381-382	240	10	0 - 37
SIC 381	164	14	0 - 39
SIC 382	76	1	0 - 20
OHT 2	59	37	-
Other OHTs	181	1	0 - 4

Table 30. Prevalence of potential exposure to ultraviolet radiation in the manufacture of metal products and machinery (SIC 381-382) according to types of industry (SIC) and occupational health title (OHT).

Group of workers	N	Prevalence (%)	Range within the group of workers
SIC 381-382	240	23	0 - 76
SIC 381	164	29	0 - 78
SIC 382	76	9	4 - 60
OHT 2	59	83	-
Other OHTs	181	7	0 - 19

Table 32. Prevalence of risk exposures (workers in %) according to their number in the manufacture of metal products and machinery (standard error in parentheses).[a]

Type of industry	Number of risk exposures			
	0 (%)	1 (%)	2 (%)	3 (%)
Manufacture of metal products	34.1 (..)	39.1 (7.4)	24.1 (6.6)	2.7 (2.8)
Manufacture of machinery	56.3 (..)	29.8 (8.4)	11.8 (7.3)	2.1 (1.3)

[a] The difference between the distributions: $\chi^2=11.75$, df=3, $p<0.01$.

Table 33. Exposures of workers to allergens and carcinogens according to their number in the manufacture (mfg) of metal products (prod) and machinery.

Exposure	Number of workers according to number of exposures								
	Mfg of metal prod				Mfg of machinery				
	0	1	2	3	0	1	2	3	
Allergen	144	15	2	3	46	24	5	0	xxx
Carcinogen	134	25	3	2	48	9	18	1	xxx

xxx = $p < 0.01$

Table 38. Workers'exposure to risk exposures according to the occupational title group and the number of risk exposures in the manufacture of metal products and machinery.

Occupational title group	N	Number of workers according to the number of risk exposures			
		0	1	2	3
1	37	4	27	6	0
2	59	5	26	13	15
3	40	10	19	10	1
4	31	21	10	0	0
5	22	12	6	2	2
6	51	36	12	3	0
1-2	96	9	53	19	15
3-4	71	31	29	10	1
5-6	73	48	18	5	2
1-3	136	19	72	29	16
4-6	104	69	28	5	2

APPENDIX II

CHOICE OF SOURCE OF INFORMATION

The sampling could have been performed with the aid of a register based on either The Register of Enterprises or The Industrial Statistics, both kept by The Central Statistical Office of Finland. The practical coverage of The Register of Enterprises for part of private industrial enterprising activity is 100 % (12). A comparison proved that both gave equal coverage in the size categories of the study. The Register of Enterprises was chosen as the information source, as it enabled an unambiguous definition of the population according to the size of the workplace.

In The Register of Enterprises the statistical unit is an enterprise, but it also contains information needed to identify workplaces. The register is based on information from the 1964 census of business enterprises, which was made more complete with information obtained from the taxation of business turnover to meet the situation at the end of 1968. Since then checking and completion inquiries have been made every other year in order to update the register to agree with the situation at the end of 1972 and 1974. The final data for 1972 were processed in May 1975 (12). In the Register of Enterprises information concerning the products and personnel of the workplaces within an enterprise have been used to define the type of industry of the enterprise (12).

APPENDIX III

Markku Nurminen and Tapani Vihma

SAMPLING SCHEME

It was decided to perform a two-way stratified sampling according to table 1 (page 96), where R=27 and C=3. With a sample size as small as 100 a customary stratification device would not permit the estimation of sampling error.

For presentation of the sampling the following notation is introduced:

- R = number of rows ($i=1,2,\ldots,R$),
- C = number of columns ($j=1,2,\ldots C$),
- P_{ij} = the (known) fraction of the total population in the ith row and the jth column (ie, in the ijth cell) of the two-way table,
- $\bar{Y}_{ij}$ = the (unknown) mean value of a survey characteristic y attached to the population units in the ijth stratum.

The marginal fractions of the population are

$$P_{i.} = \sum_j P_{ij},$$
$$P_{.j} = \sum_i P_{ij},$$

(where the dot replacing a subscript denotes summation over all values of the index).

The marginal means are

$$\bar{Y}_{i.} = \sum_j P_{ij}\bar{Y}_{ij}/P_{i.},$$
$$\bar{Y}_{.j} = \sum_i P_{ij}\bar{Y}_{ij}/P_{.j} \text{ ja}$$
$$\bar{Y}_{..} = \sum_{ij} P_{ij}\bar{Y}_{ij} = \sum_i P_{i.}\bar{Y}_{i.} = \sum_j P_{.j}\bar{Y}_{.j}.$$

Further

n_{ij} = the number of workplaces (sample units) drawn into the sample from the ith group of industry and the jth personnel size category,

$\bar{Y}_{ij}$ = the mean of y for the sampled units in the ith cell.

If no workplaces are sampled in a cell, $n_{ij} = 0$, and $\bar{Y}_{ij}$ is not defined for this cell.

Denote marginal sample frequencies by

$$n_{i.} = \Sigma_j n_{ij} ,$$

$$n_{.j} = \Sigma_i n_{ij} ,$$

so that the sample size is

$$n = \Sigma_i n_{i.} = \Sigma_j n_{.j} = \Sigma_{ij} n_{ij} = 100.$$

Likewise, denote marginal sample means by

$$\bar{y}_{i.} = \Sigma_j n_{ij} \bar{y}_{ij} / n_{i.} ,$$

$$\bar{y}_{.j} = \Sigma_i n_{ij} \bar{y}_{ij} / n_{.j} ,$$

so that the grand mean of the sample is given by

$$\bar{y}_{..} = \Sigma_i n_{i.} \bar{y}_{i.} / n = \Sigma_j n_{.j} \bar{y}_{.j} / n = \Sigma_{ij} n_{ij} \bar{y}_{ij} / n .$$

The 100 workplaces were allocated to the rows and columns by defining

$$n_{i.} = nP_{i.} \quad ; \quad n_{.j} = nP_{.j} .$$

In table 1 there were 27 rows. At this stage the smallest industries were grouped together so that the number of workplaces allocated to each row was at least one. Thus 22 types of industry formed the basis for the estimation of the mean values.

The final sample cell frequencies were not calculated according to self-weighting proportional fractions nor fixed by a marginal fraction ($n_{ij} = n_{i.}n_{.j}/n$), but instead they were made variable by an artificial randomization process: A multivariate distribution of n_{ij} was generated, satisfying the marginal conditions

$$n_{i.} = \sum_j n_{ij} \quad , \quad n_{.j} = \sum_i n_{ij} .$$

In addition, the distribution of n_{ij} was specified to have proportional expectations such that

$$E(n_{ij}) = P_{i.}P_{.j}n \quad ,$$

where E is the mathematical expectation (the expected mean value of the sample distribution). The procedure allowed, inter alia, that in those groups of industry, from which only one workplace was drawn, the size of personnel of the drawn workplace was determined randomly with a probability indicated by the corresponding marginal fractions.

The results yielded by the sampling based on random numbers are presented in table 2.

APPENDIX IV

CATALOGUE OF THE WORK TASKS

Instructions

Numbering of the workers (column 1):

Each worker included in the survey was numbered The numbering followed the production process.

Work task (column 2):

Work task was defined as all of the work regularly done by the worker. It was briefly characterized in column 2 by the occupational title.

Numbering of the subtasks (column 3):

The work task was divided into subtasks if work conditions changed from one phase of work to another.

Subtasks (column 4):

Each subtask was briefly described.

Duration of the subtask (column 5):

The average duration of each subtask was evaluated in hours per workday.

An example:

Worker number	Work task, occupational title	Subtask number	Subtask	Averge duration hours/workday
1	2	3	4	5
.				
.				
.				
3	sheet metal worker	1	cutting	2
		2	edging	2
		3	welding	3
		4	others	1

APPENDIX V

PRELIMINARY SURVEY OF WORK CONDITIONS

(filled out during the first visit to the workplace on the basis of an interview with the employer and observations of the industrial hygienist concerning work conditions)

Information about the firm as a whole

(The employer was interviewed before the workplace was surveyed.)

1. Your firm's products

Major products	Annual production (volume)
_____	_____
_____	_____
_____	_____

2. Production methods
(enclose the lay-out of the production process)

Name of the department or workroom	Number of employees	Description of the production processes
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

Information concerning a department or a workroom

(was also filled out when there was only one workroom in the firm)

1. Name of department or workroom _____

2. Additional information concerning production methods

_____

3. Products manufactured — Annual production

_____ _____

_____ _____

_____ _____

4. Raw materials used — Annual consumption (estimate)

_____ _____

_____ _____

_____ _____

5. Other chemical substances used

Name or chemical composition	Manufacturer/ seller or importer	Continuous usage	Consumption	Place of usage

etc

6. Substances known to be formed in the process

_____

_____

7. Dimensions of the workroom _____

8. Window area, about _____ m^2

9. The most recent substantial technical/technological change in the production process

Name and character of the change	Date of change
_____	_____
_____	_____

10. Changes planned for the production process

_____

Date _____

OBSERVATION FORM ON WORK CONDITIONS

(filled out during the first visit to the workplace)

Firm: _____

Department: _____

Observations concerning the production process and groups of workers

---

ILLUMINATION _____

VENTILATION _____

GENERAL ORDER/
TIDINESS _____

HEATING _____

NOISE _____

CLIMATE _____

VIBRATION _____

RADIATION _____

DUST

- organic _____
- fibrogenic _____
- metal _____
- other _____

CHEMICAL EXPOSURES

_____

_____

_____

ACCIDENT RISKS

_____

_____

APPENDIX VI

QUESTIONNAIRE FILLED OUT BY EMPLOYEES

(the questions used in this report)

1. SEX

Female 1

Male 2

2. AGE

_____years

11. WHAT IS YOUR PRESENT OCCUPATION OR WORK TASK?
Besides writing your occupational title describe the kind of work you do the most

_____

_____

_____

13. HOW LONG HAVE YOU BEEN IN YOUR PRESENT OCCUPATION?

_____ years _____ months

25. DOES YOUR SKIN COME INTO CONTACT WITH SUBSTANCES WHICH ARE HARMFUL TO IT DURING WORK?

yes 1

no 2

cannot say 3

If yes, name the substance(s).

_____

_____

APPENDIX VII

INTERVIEW ABOUT OCCUPATIONAL HEALTH CARE

(for the employer)

HAVE OCCUPATIONAL HEALTH SERVICES BEEN PROVIDED FOR THE EMPLOYEES OF THE WORKPLACE BY THE EMPLOYER (DOCTORS'S OR NURSE'S SERVICES: FOR EXAMPLE PREEMPLOYMENT EXAMINATIONS, PERIODIC MEDICAL EXAMINATIONS OR TREATMENT OF DISEASES)?
IF NOT YET ARRANGED, ARE THERE PLANS FOR PROVIDING OCCUPATIONAL HEALTH SERVICES FOR THE EMPLOYEES?

Occupational health care has been provided 1

The provision of occupational health care has been planned 2

Occupational health care has not been provided, and the provision of it has not yet been planned 3

APPENDIX VIII

A COMPARISON OF OCCUPATIONAL TITLES AND OCCUPATIONAL HEALTH TITLES

An occupational health title (OHT) is one kind of occupational title (OT). OHT differs from the traditional OT in three respects: the procedure of classification, the criteria for classification, and the grouping of OTHs according to the production process.

Procedure of classification. In the conventional classification, the same OTs reported by employers or employees are classified under an OT. On the other hand, classification under OHTs is not based on the reported OTs; it is based on each worker's work task and production method. Workers with sufficiently similar work tasks and production methods are classified under the same OHT. Therefore, the classification under OHTs is more accurate than that according to OTs because it does not contain the following sources of error associated with the use of reported OTs:

- The employee uses an occupational title which does not describe the actual task, eg, the employee uses his old OT although the work task has changed.

- The employee is not aware of his accurate OT.

- The employee may use an OT of a higher status than the OT of his current work.

- The employers use different OTs for the same work tasks.

- Both the employer and the employee may use an OT which is unknown to the classifier and is not included in the standard classification of occupations.

In the OHT classification the investigator gives the name to each OHT. The standard occupational classification can be used as the primary source when the names of the titles are decided. If a suitable title cannot be found from the official source, a title commonly used in the workplace is recommended.

The criteria for classification. The standard occupational classification (23, 35) is not sufficiently differentiated with respect to the technology, the degree of mechanization, and the degree of differentiation of work tasks. These shortcomings will become more apparent with rapid automation. Furthermore, the standard occupational classification contains OTs irrelevant to occupational health, which may confuse the classifier. Such titles are mainly related to the nature of the product.

The production process. OHTs are grouped according to the production process so that they form a sequence from the beginning to the end of the production process. There are no clear criteria related to the production process in the standard occupational classification (23, 35).

APPENDIX IX

PROCEDURE USED IN CLASSIFYING WORKERS UNDER OCCUPATIONAL HEALTH TITLES

1. The classification was based on the work task and production method of the worker, and not on the given occupational title.

2. The work task and possible subtasks (and the average durations of each) were determined first. The information was collected during two visits to the workplace. Both the employer and the employee were interviewed. Information about production methods was collected in the same way.

3. The workers whose work tasks and production methods were sufficiently similar were classified under the same occupational health title.

4. The following criteria were taken into consideration for evaluating the degree of similarity of work tasks and production methods: the degree of mechanization of work, the degree of differentation of work tasks, and the nature of the technology used. These criteria have had too little emphasis in the standard occupational classification.

5. If the worker had many subtasks, the occupational health title was determined by the subtasks of longest duration.

6. If the worker had no typical subtasks, eg, because of the versatility of the work task, the worker was not classified under any occupational health title.

7. The occupational titles of the standard occupational classification were used as occupational health titles. If a suitable title was not found from the standard occupational classification, a title that was commonly used in the workplaces was adopted.

8. In the standard occupational classification there were criteria of little significance with regard to occupational health; these were not used.

9. A classification according to occupational health titles can be carried out successfully if the major subtasks (and their durations) and production methods are determined in sufficient detail.

APPENDIX X

Markku Nurminen and Tapani Vihma

ESTIMATION

This section provides the formulas given by Bryant et al (9) for the two estimators of the population mean and their variances.

An unbiased estimate of the population mean $\bar{Y}$ is found as follows:

$$\bar{y}_U = (1/n) \sum_{ij} n_{ij} w_{ij} \quad ,$$

where it is denoted

$$G_{ij} = n^2 P_{ij} / n_{i.} n_{.j} \quad ,$$
$$w_{ij} = G_{ij} \bar{y}_{ij} \quad ;$$

its variance is

$$V(\bar{y}_U) = \frac{(n-1)}{n^3} \left[\sum_i \frac{n_i}{n_{i.}-1} \sum_j n_{ij} (w_{ij} - \bar{w}_{i.})^2 + \sum_j \frac{n_{.j}}{n_{.j}-1} \sum_i n_{ij} (w_{ij} - \bar{w}_{.j})^2 - \frac{n}{n-1} \sum_{ij} n_{ij} (w_{ij} - \bar{w})^2 \right] + \frac{s^2_p}{n} \sum_{ij} \left[P_{ij} - f(n_{i.} n_{.j}) G_{ij} \right] G_{ij} \quad ,$$

where the sample variance pooled over the cells is

$$s^2_p = \frac{\sum^e_{ij} (n_{ij}-1) s^2_{ij}}{\sum^e_{ij} n_{ij} - n_e} \quad ,$$

where e denotes summation over only the cells having two or more observations, and

$$s^2_{ij} = (1/(n_{ij}-1)) \sum_{k=1}^{n_{ij}} (y_{ijk} - \bar{y}_{ij})^2$$

(the within cell variance estimated from the sample of n_{ij} observations), n_e is the number of cells containing two or more sample values (when R=22, C=3, then RC=66 and n_e=24),

$$f(n_{i.},n_{.j}) = \frac{(n-1)}{n^2}\left[1+\left\{\frac{n-n_{i.}n_{.j}}{n}\right\}\left\{\frac{1}{n_{i.}-1}+\frac{1}{n_{.j}-1}-\frac{1}{n-1}\right\}\right] ,$$

$$\bar{w}_{i.} = \Sigma_j n_{ij}w_{ij}/n_{i.} ,$$

$$\bar{w}_{.j} = \Sigma_i n_{ij}w_{ij}/n_{.j} ,$$

$$\bar{w}_{..} = \Sigma_{ij} n_{ij}w_{ij}/n .$$

The biased estimator is simpler in construction than the unbiased one, to which the former reverts when the cell fractions (P_{ij}) and sample sizes (n_{ij}) are proportional to the marginal fractions (ie, when $P_{ij}=P_{i.}P_{.j}$). The estimator takes the form

$$\bar{y}_B = (1/n)\,\Sigma_{ij} n_{ij}\bar{y}_{ij} .$$

Its variance B is obtained by replacing w_{ij} by the sample means $\bar{y}_{ij}$ in the formula for the variance $V(\bar{y}_U)$ and by setting the factor G_{ij} equal to unity.

In general the variance of the biased estimator is smaller than that of the unbiased one. The bias is meaningless when the cell frequencies are proportional to the marginal distributions.

The amount of bias is

$$B = E(\bar{y}_B) - \bar{y} ,$$

which was estimated by

$$b = \Sigma_{ij}\left[\frac{n_{i.}n_{.j}}{n^2} - P_{ij}\right]\bar{y}_{ij} .$$

In practice the bias turned out to be diminutive so that the biased and unbiased estimator of the mean yielded values of nearly the same magnitude. The standard errors of the estimators also proved to be of the same order of magnitude.

Formulas for the estimation of marginal means of partitioned samples were not provided in the orginal article by Bryant et al (9), and the plan of the authors to present them in a later paper apparently did not materialize (HO Hartley, personal communication). Thus the estimator with the smallest variance was chosen from the four candidates, on the basis of empirical results. The formulas for the row and column means are as follows:

$$\bar{y}_{i.} = \frac{1}{\sum_j n_{ij} G_{ij}} \sum_j n_{ij} G_{ij} \bar{y}_{ij} \quad ,$$

$$\bar{y}_{.j} = \frac{1}{\sum_i n_{ij} G_{ij}} \sum_i n_{ij} G_{ij} \bar{y}_{ij} \quad .$$

To estimate the variance of these estimators of marginal means, a simple approximate procedure was applied based on the range of a partitioned sample. The mean error of an estimate of the sample mean was calculated with the formula:

$$s_{\bar{y}} = w_n A_n \quad ,$$

where w_n is the range of the values in the partitioned sample or the difference between the largest and smallest value of variable y in a sample of size n, $y_{(n)} - y_{(1)}$.

The constants A_n depend on the size of the sample (n). The mean errors of partitioned samples including deviating values became large, since they were thus based on a range.

In the computation a slightly different row partition from that of table 1 was employed in order to obtain an increased homogeneity of the strata according to type of industry. For comparison, the group of industries 381-385 (metal industry) was also considered as

a uniform stratum. Bakeries (SIC 331179) and printing shops (SIC 342011-342015) were regarded as separate, homogeneous, partitioned samples, for which ordinary (unweighted) arithmetic mean values and their deviations were computed.

Estimations were not performed for variates whose prevalence in the sample was less than 1 %.

In many points studied, the sample means were close to the estimated population means since the sample strata cells were nearly proportional to the marginal distributions.

APPENDIX XI

EVALUATION OF PHYSICAL WORK LOAD ON THE BASIS OF STATIC WORK LOAD AND DYNAMIC WORK LOAD

Static work load

Dynamic work load

	1	2	3	4
1	1	2	3	4
2	2	3	4	4
3	3	4	4	4
4	4	4	4	4

1 = light
2 = moderate
3 = heavy
4 = very heavy

APPENDIX XII

EXAMPLES OF THE CLASSIFICATION BY OCCUPATIONAL HEALTH TITLE (OHT) IN INDUSTRIES 381-382

OHT GROUP	OHT TITLE	WORK TASK/ SUBTASKS	DURATION HOURS/DAY	OCCUPATIONAL TITLE USED IN WORKPLACE
1	Sheet metal cutter	1 cutting 2 edging 3 packing	5 2 1	Mate
1	Sheet metal cutter	1 cutting	8	Sheet metal cutter
1	Edger	1 edging 2 cutting 3 packing	5 2 2	Mate
1	Metal presser	1 pressing 2 assembly 3 other work	5 2 1	Phase worker
2	Welder	1 welding 2 grinding 3 assembly	5 2 1	Metalworker
2	Welder	1 welding 2 grinding 3 work supervision	6 1 2	Foreman
2	Welder	1 welding 2 edging 3 cutting	5 2 1	Metalworker
2	Sheet metal worker	1 edging 2 welding 3 cutting	3 3 2	Sheet metal worker
2	Sheet metal worker	1 welding 2 machining 3 assembly	3 2 3	Filer
3	Lather (nonautomatic)	1 lathing	8	Lather
3	Driller (nonautomatic)	1 drilling 2 latheing	5 3	Driller
3	Lather (nonautomatic)	1 latheing 2 drilling 3 planning	4 2 2	Product designer

4	Assembler	1 assembly 2 processing 3 welding	6 1 1	Filer
4	Assembler	1 assembly 2 work supervision	5 3	Foreman
4	Assembler	1 assembly	8	Assembler
5	Spray painter	1 spray painting 2 other work	6 2	Spray painter
6	Warehouse worker	1 warehouse work	8	Storeman
6	Phase worker	1 assembly	8	Manual worker

APPENDIX XIII

EXAMPLES OF THE CLASSIFICATION BY OCCUPATIONAL HEALTH TITLE (OHT) IN THE PRINTING INDUSTRY

OHT GROUP	OHT TITLE	WORK TASK/ SUBTASKS	DURATION HOURS/DAY	OCCUPATIONAL TITLE IN THE WORKPLACE
1	Typesetter (manual)	1 typestting	8	Typesetter
1	Typesetter (machine)	1 typesetting (machine)	6	
		2 typesetting (manual)	2	Typesetter
1	Typesetter (machine)	1 typesetting (machine)	5	Typesetter
		2 binding	3	
2	Poster	1 posting	8	Poster
2	Poster	1 posting	4	Asst foreman
		2 photographing	2	
		3 administration	2	
2	Poster	1 posting	5	Foreman
		2 photographing	2	
		3 work supervision	1	
3	Paper cutter	1 cutting	8	Paper cutter
3	Paper cutter	1 cutting	6	Foreman
		2 work supervision	2	
3	Paper cutter	1 cutting	6	Paper cutter
		2 driving	2	
4	Relief printer	1 printing	8	Printer
4	Relief printer	1 relief printing	5	Relief printer
		2 offset printing	3	
5	Offset printer	1 offset printing	6	Offset printer
		2 cutting	1	
		3 binding	1	
5	Offset printer	1 offset printing	7	Offset printer
		2 cutting	1	
6	Binder	1 binding	7	Binder
		2 stapling	1	

	Binder	1 binding	6	Binder
		2 folding machine	1	
		3 packing	1	
7	(no title)	1 typesetting (manual)	3	Typesetter
		2 cutting	3	
		3 binding	2	
7	Foreman	1 work supervision	5	Foreman
		2 proof reading	2	
		3 printing work	1	
7	Messenger	1 messenger duties	5	Assistant
		2 cleaning	3	