ORIGINAL ARTICLE

Mortality from non-malignant diseases in a cohort of female pulp and paper workers in Norway

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Objectives: The objective of the present study was to investigate the risk of death from non-malignant diseases in female pulp and paper workers in Norway.

Methods: A total of 3143 women first employed between 1920-93 were included in the study cohort. Information about each cohort member was obtained from personnel record files in the mills in order to identify employment periods and job categories. Data on cause and date of death were added by linkage to the Cause of Death Register using unique personal identification numbers. The follow up period was 1951-2000. Standardised mortality ratios (SMRs) with 95% confidence intervals (95% CIs) were calculated using the national female mortality rates as reference. Poisson regression analysis was used to examine internal relations between the duration of employment in paper departments and the risk of death from selected causes. Relative risks (RRs) and 95% CIs were calculated.

Results: The study showed a significantly increased risk for total non-malignant mortality (SMR = 1.14, 95% CI 1.05 to 1.24), mainly due to increased mortality from ischaemic heart disease (SMR = 1.22, 95% CI 1.03 to 1.43) and cerebrovascular diseases (SMR = 1.16, 95% CI 0.94 to 1.42). Analysis by department showed the highest risk of death in paper department workers with short term employment. Internal analyses showed a 5% and 9% increase in risk of dying from ischaemic heart disease and respiratory diseases, respectively, among paper department workers exposed to paper dust. The risk decreased with increasing duration of employment.

Conclusion: The increased risk of ischaemic heart diseases and respiratory diseases seen among employees of paper departments may be related to exposure to paper dust.

Few studies have addressed mortality from non-malignant diseases among women in industrial jobs. The reason for this may be that women traditionally have been in the minority in these occupational groups, their employment and follow up periods may have been shorter, and they are often assumed to hold less exposed jobs than men. In many countries women entered the workforce later than men did. In Norway the percentage of women working outside the home was less than 30% in 1960, less than 40% in 1980, increasing to almost 70% in 1990.¹ Increasing employment in industries where women were largely excluded in the past necessitates studies on female workers mainly because gender differences might cause different disease outcome in men and women.²⁻⁴

Worldwide, men have constituted the main part of the workforce in the pulp and paper industry, and most studies have reported results only for men or, in some cases, for both genders merged.⁵ The pulp and paper industry is a very old industry in Norway, operating since 1870. Women have through all times constituted approximately one tenth of the workforce among paper workers and the classical workplace has been in paper departments as paper sorters. Many girls started work at a very young age; in 1910 one half of them were aged under 20 years.⁶

A number of potentially hazardous exposures are used in the production of pulp and paper. Respiratory irritants such as paper and wood dust, sulphur, and chlorine compounds have been suspected to cause increased risk of death from respiratory and cardiovascular diseases. However, a review paper on health effects from work in pulp and paper mills pointed out that results are not conclusive.⁵

One of the main exposures among women in the present study is dust (mainly paper dust) released into the work atmosphere during cutting and sorting of paper. Inhalation of

dust is hypothesised to lead to inflammation in lung tissue that increases plasma fibrinogen, which further increases the risk of ischaemic heart disease and myocardial infarction.⁷ Organic dust exposure has been suspected to explain the increased risk of heart diseases in several occupational groups.⁸⁻⁹ Workers exposed to high levels of paper dust have shown increased mortality from asthma and chronic obstructive pulmonary diseases,¹⁰ and a number of studies in pulp and paper workers have shown increased mortality from cardiovascular diseases.¹¹⁻¹⁴ Increased risk for diabetes mellitus has also been observed in pulp and paper workers.¹⁵⁻¹⁶ Sulphur and chlorine compounds have been common airway irritants in the production departments.

In the early 1990s an international cohort of pulp and paper workers and a job exposure matrix (PAPDEM) was established by the International Agency for Research on Cancer (IARC). Norwegian workers constitute 27% of the total cohort and 13% of all measurements are from Norwegian mills. Several studies have been generated from the international cohort describing occupational exposures in pulp and paper mills and health effects associated to work in this industry.¹⁷⁻²⁰

The purpose of the present study was to investigate the risk of death from non-malignant diseases among female pulp and paper workers in Norway, and especially the risk of death from cardiovascular and respiratory diseases related to occupational exposure to paper dust, sulphur, and chlorine compounds.

Abbreviations: COPD, chronic obstructive pulmonary disease; IARC, International Agency for Research on Cancer; ICD, International Classification of Diseases; Obs, observed number of deaths; PAPDEM, pulp and paper department exposure matrix; SMR, standardised mortality ratio

METHODS

Included in the present study are those pulp and paper mills in Norway operating at the time the cohort was established, except one mill that did not want to participate. The study cohort was defined as all female employees hired for a total period of at least one year in one or more of 11 pulp and paper mills, between 1920 and 1993 and who were alive in 1951 or born later. Initially 4605 women were included in the study. Women working in administrative jobs only were considered as unexposed and excluded from the study ($n = 1087$). Additionally, rayon plant workers ($n = 15$) were not included. Three hundred and sixty women were lost to follow up, probably as a result of changes in their surname upon marriage. Altogether 3143 women were included in the final cohort. Each cohort member was followed for the event of death from 1 January 1951 when the central death register was established, or date of hire if later, until 31 December 2000 or the time of death or emigration if before this date. About 58% of the workers were born before 1940. The total number of person-years of follow up was 102 996.

By using the personal identification number given to all Norwegian citizens alive in 1960, the cohort was linked to the Cause of Death Register at Statistics Norway. Women who died before 1960 were identified by date of birth and name. Causes of death have through the follow up period been coded according to the International Classification of Diseases (ICD) versions 6 through 10. All versions were converted to the ICD-9 version, and categorised in comparable groups over time (table 1). Asthma has been registered as a separate diagnosis only after 1960; earlier it was included in chronic obstructive pulmonary disease (COPD). In the present study asthma was therefore included in COPD.

Information about each cohort member was collected from personnel record files in the mills to identify all jobs and employment periods.

Duration of employment was used as an exposure indicator and the cohort was divided into two subcohorts based on length of employment. The group of short term workers was defined as having less than three years of total employment and long term workers as having three or more years of employment. Duration was initially categorised in more than two groups, but as no effect on risk estimates was seen by this subdivision, we present duration of employment only as less than three years or more than three years. As an indicator of possible changes in exposure over time we used

year of first employment in four periods; 1920–39, 1940–59, 1960–79, 1980–93. Mortality ratios were estimated for paper departments ($n = 1724$), production departments (sulphite and sulphate, $n = 187$), non-production departments (cleaners, drivers, canteen workers a.o., $n = 1324$), and maintenance departments ($n = 145$). Some workers (8.8%) had been employed in more than one department and were then counted in all of them in the analyses.

Work in paper departments was used as indicator of dust exposure. This assumption was based on information from PAPDEM on prevalence and level of exposure in different departments.¹⁷ In the paper departments about 85% of the workers were employed in paper/board winding activities, and 15% as paper machine operators. In these areas the prevalence of exposure was assumed to be high (>95% of the workers have been exposed) and the exposure level was medium (0.7–5.0 mg/m³).

The SMRs were estimated by comparing the observed number of deaths with the expected number for the entire national female population. The expected numbers were calculated from age specific mortality rates for five-year age groups and five-year observation periods. The 95% confidence intervals (95% CIs) were calculated assuming a Poisson distribution of the observed numbers.

Internal analyses were carried out to investigate the risk of death from non-malignant diseases according to duration of employment. Women ever working in paper departments were considered as exposed to paper dust and women in all other departments as never exposed. The duration of employment was categorised according to the number of years employed (1–2 years, 3–14 years, 15 years or more). Poisson regression analysis was used to examine the relation between duration of employment in paper departments and risk of death from selected causes. Relative risks (RRs) and 95% CIs were calculated.

The statistical package Epicure was used to calculate the risk estimates and the 95% CIs both in the external and internal analyses.²¹ The Data Inspectorate and The Norwegian Directorate of Health and Social Services approved the study.

RESULTS

Table 1 shows the risk estimates for selected causes of death among short and long term workers. The all-cause mortality of non-malignant diseases was significantly elevated with 516 deaths compared to 453 expected (SMR = 1.14, 95% CI

Table 1 Standardised mortality ratios (SMRs) with 95% confidence intervals (95% CIs) for selected causes of death in female pulp and paper workers in Norway by duration of employment

Cause of death	ICD 9th revision	Duration of employment								
		<3 years			≥3 years			Total		
		Obs	SMR	95% CI	Obs	SMR	95% CI	Obs	SMR	95% CI
All non-malignant causes	000–139, 210–999	100	1.33	1.09–1.62	416	1.10	1.00–1.22	516	1.14	1.05–1.24
All cardiovascular diseases	390–459	54	1.33	1.00–1.74	261	1.14	1.01–1.29	315	1.17	1.05–1.30
Ischaemic heart disease	410–414	32	1.73	1.18–2.44	115	1.12	0.94–1.35	147	1.22	1.03–1.43
Cerebrovascular diseases	430–438	10	0.83	0.40–1.52	85	1.22	0.97–1.51	95	1.16	0.94–1.42
Rheumatic/valve	425–429	6	1.10	0.40–2.40	31	1.03	0.70–1.46	37	1.04	0.73–1.43
Other cardiovascular	420–423	6	1.33	0.49–2.89	30	1.12	0.76–1.60	36	1.15	0.81–1.59
All respiratory diseases		14	1.79	0.98–3.01	43	1.01	0.73–1.36	57	1.13	0.86–1.47
All respiratory	460–519	6	1.92	0.71–4.18	13	0.99	0.53–1.69	19	1.17	0.70–1.82
COPD	490–494, 496	6	1.52	0.56–3.31	27	1.06	0.70–1.54	33	1.12	0.77–1.57
Pneumonia	480–487	2	2.66	0.32–9.62	3	0.79	0.16–2.31	5	1.10	0.36–2.56
Diabetes mellitus	250	3	1.85	0.38–5.41	7	0.98	0.39–2.02	10	1.14	0.55–2.10
Urinary system/genitalia	580–594	2	1.34	0.16–4.85	9	1.25	0.57–2.37	11	1.26	0.63–2.26
Digestive system	520–579	6	1.60	0.59–3.49	17	1.00	0.58–1.60	23	1.11	0.70–1.66
Sudden death/violent	E800–E929	12	1.65	0.85–2.86	23	1.01	0.64–1.51	35	1.16	0.81–1.62
Other non-malignant causes		9	0.66	0.30–1.25	56	0.95	0.72–1.23	65	0.89	0.69–1.14

*Chronic obstructive pulmonary disease (asthma included).
Follow up period 1951–2000.

Table 2 Standardised mortality ratios (SMRs) with 95% confidence intervals (95% CIs) for selected causes of death in paper department workers, among short and long term workers

Causes of death	ICD 9th revision	Duration of employment in paper departments					
		<3 years			≥3 years		
		Obs	SMR	95% CI	Obs	SMR	95% CI
All non-malignant causes	000–139, 210–999	71	1.41	1.10–1.78	216	1.16	1.02–1.33
All cardiovascular diseases	390–459	37	1.36	0.96–1.88	129	1.15	0.97–1.37
Ischaemic heart disease	410–414	24	1.94	1.24–2.89	61	1.21	0.93–1.56
Respiratory diseases	460–519	13	2.43	1.29–4.15	25	1.21	0.79–1.79

Follow up 1951–2000.

1.05 to 1.24) in the whole cohort. The number of person-years for women working <3 years or ≥3 years were 34 745 and 68 251 respectively. The risk was significantly higher both among short term and long term workers.

The elevation of all cause mortality was mainly caused by increased risks of cardiovascular diseases. For short and long term workers the SMR values for cardiovascular diseases were 1.33 (95% CI 1.00 to 1.74) and 1.14 (95% CI 1.01 to 1.29), respectively (table 1). Ischaemic heart disease and cerebrovascular diseases constituted the major part of the cardiovascular deaths. Altogether 147 cases of ischaemic heart disease were observed and for women with less than three years of employment the risk was significantly increased. The risk estimate for cerebrovascular diseases was increased close to significance for long term workers.

The number of deaths from respiratory diseases was 57 versus 50 expected for the total group, pneumonia counting 33 of the cases. Only five deaths from asthma were observed versus 5.8 expected in the period 1960–2000, and were included in the number of COPD causes. Risk of death from diabetes, diseases of the urinary system and genitalia, digestive system, and sudden death was approximately as expected (table 1).

No clear trend in risk of death, according to period of first employment, was seen for any disease group. Those with first employment in the periods 1940–59 and 1960–79 had a significantly increased risk of dying from all causes combined, and risk of ischaemic heart disease was higher in women first employed in the periods 1920–39 and 1960–79. However, the risk estimates were increased close to significance for several of the other time periods (not shown in table).

Separate analyses were done according to work in the different departments. Results for the subgroup working in the paper departments are presented in table 2. Risk estimates were highest among the short term workers, with significant elevation for all non-malignant causes, ischaemic

heart diseases, and respiratory diseases. Somewhat lower elevations were seen among the long term workers, where only the mortality of all causes combined reached statistical significance. Production workers had a non-significantly increased risk of ischaemic heart diseases based on 15 deaths, SMR = 1.60 95% CI 0.90 to 2.64 (not shown in table). No increase in risk estimates was seen for work in non-production or maintenance departments (not shown).

Table 3 shows that women ever employed in paper departments have a 5% and 9% increase in risk of dying from ischaemic heart disease and respiratory diseases, respectively, compared to women never employed in paper departments. For respiratory diseases decreasing relative risks with increasing duration of employment was seen. The risk of ischaemic heart disease was increased close to significance among women with the shortest employment time.

DISCUSSION

Our investigation showed that women working in the Norwegian pulp and paper industry had a higher mortality from all non-malignant diseases than the general female population, mainly due to increased mortality from cardiovascular diseases. Internal analyses showed that women ever employed in paper departments had a slightly higher risk of dying from ischaemic heart disease and respiratory diseases compared to women never employed in paper departments. This was most pronounced among short term employees.

Increased risk of cardiovascular diseases is consistent with other investigations in male pulp and paper workers.^{11–14} Only one of these studies reported risk estimates for women separately and found no increased risk among them.¹² In the present study the higher risk among paper department workers may be connected to paper dust exposure.

In contrast to other studies of pulp and paper workers we did not find any overall increased mortality from respiratory diseases. In male, or predominantly male, cohorts, workers

Table 3 Relative risks (RRs) and 95% confidence intervals (95% CIs) for selected causes of death among women employed in paper departments

Duration of employment in paper departments	All cardiovascular diseases		Ischaemic heart disease		Respiratory diseases	
	ICD 9th revision (390–459)		ICD 9th revision (410–414)		ICD 9th revision (460–519)	
	RR	95% CI	RR	95% CI	RR	95% CI
Never	1.00		1.00		1.00	
Ever	1.00	0.91–1.10	1.05	0.92–1.20	1.09	0.88–1.36
1–2 years	1.00	0.70–1.44	1.56	0.97–2.52	2.86	1.40–5.86
3–14 years	0.96	0.73–1.28	1.07	0.70–1.63	1.87	0.98–3.57
≥15 years	1.02	0.74–1.39	1.21	0.77–1.90	1.02	0.43–2.42

Duration of exposure is divided in three categories.

exposed to high levels of paper dust have shown increased mortality from asthma and chronic obstructive pulmonary diseases.¹⁰ Airway inflammation²² and respiratory symptoms^{23, 24} have been found in dust exposed pulp and paper workers and increased risk of asthma in groups exposed to irritant gases.^{25, 26} On the other hand an international study on pulp and paper workers and sulfur dioxide exposure did not show increased risk of death from bronchitis, emphysema, or asthma.¹⁹

The internal analysis of our study showed that the risk of death from respiratory diseases and ischaemic heart diseases in paper department workers decreased by longer employment period. The relative risk for respiratory diseases was significantly increased for workers employed less than three years. The main contamination in the work atmosphere of paper departments is paper dust, from sorting and packaging of paper. We cannot exclude the possibility that paper dust may have affected the development of respiratory diseases. An increased risk among short term workers is however a common observation in male industrial workers and is often explained as a healthy worker effect, characterised typically by lower relative mortality in an occupational cohort compared to the general population. This selection bias occurs because relatively healthy individuals are more likely to be employed and to remain employed.²⁷ In the present study it might be that the short term workers who leave a dusty workplace are those most sensitive for respiratory symptoms. It has been shown that such symptoms are significant predictors of mortality up to 30 years later.²⁸ A previous study has shown a stronger selection of healthy men than women into the workforce, while the health related selection out of the workforce was strongest for women.²⁹

Male and female workers may have had variations in duration and magnitude of exposures even though they have worked in the same departments. In the present cohort a higher proportion of women were employed as short term workers (28%) than their male colleagues (19%) who have been previously investigated.³⁰ Furthermore, exposure to other airway irritants than dust may differ between genders, as women with the same job title as men may well perform different tasks.³¹

Employees who stay for a short time in a workplace and change jobs frequently are often less educated and have a 25–30% higher prevalence of smoking than those with higher education.³² Smoking is a well known risk factor for cardiovascular and respiratory diseases. Investigations confirm positive associations between smoking and death from all-cause mortality, as well as mortality from respiratory disease and cardiovascular diseases.^{33, 34} In our study no information on smoking habits was available. However, from the cancer incidence study it is known that the risk of lung and bladder cancer was significantly increased among short term workers.³⁵ These are both smoking related cancers, and may indicate a high smoking prevalence in this group, which could explain the increase in risk estimates. Smoking habits and their confounding effect on lung cancer and coronary heart disease rates were evaluated in Finnish pulp and paper workers of both genders. The conclusion was that smoking could not completely explain the observed excess for both diseases, and that occupational factors may also be involved.³⁶

We did not see a clear association between period of first employment and selected causes of death. One could expect a higher risk of death from ischaemic heart diseases and respiratory diseases for those employed in the earliest periods of operation, when the exposure to dust and other agents in the work atmosphere was highest. Data from PAPDEM showed that the working processes took place at stations with paper machines open in the period 1920–50, which

gradually improved with the use of ventilated rooms from 1950–75, and since then has taken place solely in ventilated rooms.

Shift work is a suspected risk factor for cardiovascular diseases. A study among male pulp and paper industry workers in Sweden reported a significantly higher risk of death from coronary heart disease for workers with more than 30 years of shift work.³⁷ We know that the pulp and paper industry in Norway runs continuously, but only a small number of the women in our study have been shift workers. No information was however available on an individual level.

The risk of death in other departments than the paper department was approximately as expected in the general population. A 60% increased risk of ischaemic heart disease was seen in production departments, but a possible association to sulphur or chlorine exposure is difficult to interpret due to the small number of workers.

Exposure to microorganisms and endotoxins may be related to respiratory symptoms³⁸ and both have been considered as a potential exposure in paper mills. The greatest concern in this respect has been for workers in pulp mills handling fresh logs and in the wet end of the paper mills.⁵ The women in the present study had not been working in these departments.

CONCLUSION

Our investigation among female pulp and paper workers in Norway showed an increased risk of dying from all non-malignant diseases combined. The risk of cardiovascular diseases was significantly increased overall, specifically as a result of the increased risk of dying from ischaemic heart and cerebrovascular diseases. Internal comparisons indicate an association between short term employment in paper departments and risk of dying from ischaemic heart and respiratory diseases, possibly related to paper dust exposure. The results should be interpreted with caution because no information on possible confounding variables—in particular smoking—was available.

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