ORIGINAL ARTICLE

Occupational risk factors for nasopharyngeal cancer among female textile workers in Shanghai, China

W Li, R M Ray, D L Gao, E D Fitzgibbons, N S Seixas, J E Camp, K J Wernli, G Astrakianakis, Z Feng, D B Thomas, H Checkoway

Occup Environ Med 2006;**63**:39–44. doi: 10.1136/oem.2005.021709

See end of article for authors' affiliations

Correspondence to: Dr H Checkoway, Department of Environmental and Occupational, Health Sciences, School of Public Health and Community Medicine, University of Washington, Box 357234, Seattle, WA 98195-7234, USA; checko@u.washington.edu

Accepted 15 July 2005

Aims: To investigate whether occupational exposure to dusts and chemicals in the Chinese textile industry are associated with risk of nasopharyngeal cancer.
Methods: Sixty seven nasopharyngeal carcinoma (NPC) cases identified during 1989–98 and a random sample (n = 3188) of women were included in a case cohort study nested in a cohort of 267 400 women textile workers in Shanghai, China. A complete occupational history of work in the textile industry was obtained for each woman. A job exposure matrix developed by experienced industrial hygienists was used to assess exposures to specific dusts and chemicals.
Results: Risk of NPC is associated with cumulative exposure to cotton dust. The hazard ratio for women cumulatively exposed to >143.4 mg/m^3 $\times$ years of cotton dust was 3.6 (95% CI 1.8 to 7.2) compared with unexposed women. Trends of increasing risk were also found with increasing duration of exposure to acids and caustics (p = 0.05), and with years worked in dyeing processes (p = 0.06). Women who worked at least 10 years in dyeing processes had a 3.6-fold excess risk of NPC (95% CI 1.0 to 12.1).
Conclusions: Occupational exposure to cotton dust, acids, and caustics, and work in dyeing and printing jobs in the textile industry may have increased risk of NPC in this cohort.

Nasopharyngeal carcinoma (NPC) is endemic in southern China, other parts of southeast Asia, north Africa, and among Eskimos, with annual incidence rates as high as 20 per 100 000.[1] In China, the highest rates are in Southern China.[2] Rates generally decline from South to North China. Intermediate rates of four and two per 100 000 were reported for males and females in Shanghai, respectively.[3]

A link between NPC and infection with the Epstein-Barr virus (EBV) is well documented. However, more than 95% of adults in all ethnic groups worldwide are healthy carriers of EBV;[4] therefore, additional cofactors are undoubtedly required for the malignancy to develop.

Some environmental exposures may cause NPC. One of the strongest identified risk factors is salted fish and other preserved foods, especially when consumed during childhood.[3 5] Increased NPC risks have inconsistently been associated with cigarette smoking, alcohol intake, and low intake of fruit and vegetables.[1 3 6]

Several population based case control studies have shown an increased risk of NPC in relation to occupational exposure to formaldehyde,[7 8] although the evidence is inconsistent.[2] Wood dust may also increase risk. A pooled reanalysis of cancer mortality among five cohorts of workers in wood related industries showed a significantly increased risk of NPC (SMR 2.4; 95% CI 1.1 to 4.5) in relation to wood dust exposure.[9] A case control study conducted in newspaper printing workers linked printing occupations to an increased risk of NPC.[10]

Employment in the textile industry can entail exposures to various dusts (for example, cotton, wool, silk, and synthetic fibres) and chemicals (for example, dyes, inks, formaldehyde, benzene). There are reports of increased risks for several malignancies in textile workers, including nasal cancer, sinonasal cancer,[11] oral and pharyngeal cancer,[12 13] and colorectal and bladder cancer.[14] Increased risk for sinonasal cancer in workers exposed to cotton dust, and in workers involved in spinning or weaving was observed in a meta-analysis of epidemiological studies.[15] To our knowledge, risk of NPC in relation to textile exposures has not been investigated previously. We conducted a case cohort study nested in a cohort of 267 400 female textile workers in Shanghai, China to investigate possible occupational risk factors for nasopharyngeal and sinonasal carcinomas.

MATERIALS AND METHODS

Cohort population and case definition

The study population included 267 400 female employees in 526 factories in the Shanghai Textile Industry Bureau (STIB) who had been enrolled from October 1989 to October 1991 in a randomised trial of breast self examination (BSE).[16 17] All currently working and retired female employees, who were born between 1 January 1925 and 31 December 1958, were eligible to participate in the trial. Thirty four former medical workers, who were trained to be BSE trial field workers, trained approximately 5000 factory medical workers to administer a baseline questionnaire that elicited data on smoking, alcohol use, and reproductive history.

Both active and retired employees received routine health care through health clinics in their factory of employment. A detailed description of incident cancer case finding and diagnostic confirmation has been described previously.[18] All cancers diagnosed from 1989 to 1998 were reported by clinic workers to a cancer and death registry operated by the STIB Station for the Prevention and Treatment of Cancer. Cancer diagnoses were confirmed by computer matching with records from the Shanghai Cancer Registry and by medical record review. For this study, 76 women with primary NPC

Abbreviations: BSE, breast self examination; EBV, Epstein-Barr virus; JEM, job exposure matrix; NPC, nasopharyngeal carcinoma; OHRP, Office for Human Research Protections; STIB, Shanghai Textile Industry Bureau

Table 1 Characteristics of all subjects at baseline

	NPC (n = 67)		Sinonasal cancer (n = 10)		Non-cases subcohort (n = 3187)	
	n	%	n	%	n	%
Age (years)						
30–39	20	29.9	3	30.0	479	15.0
40–49	17	25.4	2	20.0	463	14.5
50–59	21	31.3	3	30.0	1181	37.1
60–69	9	13.4	2	20.0	1064	33.4
Alcohol consumption						
Never	58	86.6	10	–	2611	81.9
Ever	9	13.4	0	–	576	8.1
Cigarette use						
Never	64	95.5	10	–	3042	95.5
Ever	3	4.5	0	–	145	4.5

(ICD9 codes 147.0, 147.2, 147.3, 147.9) and 10 women with malignancies of the nasal cavity and paranasal sinuses (ICD9 codes 160.0, 160.2, 147.9) were identified from the STIB cancer registry and their diagnoses were subsequently confirmed. Of the 76 confirmed NPC cases, we were able to obtain the histological classifications for 59 cases (78%) and occupational history information for 67 cases.

Case cohort design

We used a case cohort study design[19] to explore associations between occupational exposures and risks of various cancers, including NPC and sinonasal cancer. A subcohort of 3188 women was randomly selected from the cohort for comparison with multiple cancer case groups. The subcohort was frequency matched by five year age group to correspond to the age distribution of all cancer cases. One woman with NPC was also included in the subcohort. Follow up began at the time of enrollment in the BSE trial, and ended at subjects' dates of cancer diagnosis, death, or transfer out of the STIB, or at the termination of the study on 31 December 1998.

Exposure assessment

A complete occupational history in the textile industry was collected, including employment dates, workshop, and task description, by abstracting the relevant information from employment records, or interviewing the woman's supervisor or co-workers. If the work history information was incomplete or unavailable from these sources, the woman was interviewed by telephone or in person (10% of study subjects). All of the contacted women agreed to be interviewed.

A factory profile form was used by industrial hygienists in Shanghai to record for each factory the production processes, type of workshops, and historical measurements of hazardous exposures since the establishment of the factory. This information was obtained from the factory or from the district branch of the Shanghai Centers for Disease Control and Prevention. Related production processes were then combined into 17 groups for analyses.

A job exposure matrix (JEM) was developed by our team of industrial hygienists. The JEM was based on a composite of two sources: (1) an a priori assessment of exposures by process developed by US industrial hygienists to classify fibre/process combinations according to the likely presence of various classes of dusts, chemicals, and physical agents, and (2) the frequency of reporting of exposures by process on the Factory Profile form; agents that were reported with more than 30% frequency in a specific process were classified as exposed. The industrial hygienists judged whether each specific job resulted in exposure to the six major fibre dusts

Table 2 Hazard ratio estimates of nasopharyngeal cancer in relation to working in job categories

Job category	Cases	Non-cases	HR*	95% CI	p for trend
Cotton handing, processing, spinning					
Never	52	2589	1.0	Reference	
<10 years	4	123	1.9	(0.7 to 5.3)	
⩾10 years	11	475	1.3	(0.6 to 2.4)	0.40
Mixed fibre handling processing spinning process					
Never	59	2744	1.0	Reference	
<10 years	2	126	0.8	(0.2 to 3.6)	
⩾10 years	6	317	1.0	(0.4 to 2.3)	0.89
Dyeing					
Never	63	3131	1.0	Reference	
<10 years	1	19	1.8	(0.2 to 14.1)	
⩾10 years	3	37	3.6	(1.0 to 12.1)	0.06
Finishing					
Never	65	3147	1.0	Reference	
<10 years	1	13	2.6	(0.3 to 21.3)	
⩾10 years	1	27	1.6	(0.2 to 12.5)	0.46
Weaving					
Never	51	2068	1.0	Reference	
<10 years	4	231	0.7	(0.3 to 2.1)	
⩾10 years	12	688	0.6	(0.3 to 1.2)	0.12
Printing					
Never	64	3162	1.0	Reference	
<10 years	2	8	9.2	(1.7 to 48.9)	
⩾10 years	1	17	2.0	(0.3 to 16.3)	0.15
Cutting/sewing					
Never	59	2892	1.0	Reference	
<10 years	2	86	0.9	(0.2 to 3.9)	
⩾10 years	6	209	1.3	(0.6 to 3.2)	0.57
Warehouse, packing, quality control					
Never	59	2667	1.0	Reference	
<10 years	3	182	0.7	(0.2 to 2.1)	
⩾10 years	5	338	0.6	(0.3 to 1.6)	0.23

*HR, age adjusted hazard ratio.

Table 3 Hazard ratio estimates of nasopharyngeal carcinoma in relation to the occupational exposures classified by job exposure matrix

Exposure	Cases	Non-cases	HR*	95% CI
Cotton dust				
<1 year	19	1247	1.0	Reference
⩾1 year	48	1940	1.8	(1.1 to 3.2)
Wool dust				
<1 year	61	2742	1.0	Reference
⩾1 year	6	445	0.6	(0.3 to 1.5)
Silk dust				
<1 year	64	3027	1.0	Reference
⩾1 year	3	160	0.9	(0.3 to 3.0)
Synthetic fibre dust				
<1 year	42	1930	1.0	Reference
⩾1 year	25	1257	0.9	(0.5 to 1.5)
Non-textile dust				
<1 year	61	2674	1.0	Reference
⩾1 year	6	513	0.5	(0.2 to 1.2)
Solvents				
<1 year	53	2739	1.0	Reference
⩾1 year	14	448	1.3	(0.7 to 2.5)
Bleaching agents				
<1 year	64	3142	1.0	Reference
⩾1 year	3	45	2.4	(0.7 to 8.2)
Acids, bases, and caustics				
<1 year	56	2929	1.0	Reference
⩾1 year	11	258	1.8	(0.9 to 3.6)
Dyes				
<1 year	62	3092	1.0	Reference
⩾1 year	5	95	2.1	(0.8 to 5.5)
Inks				
<1 year	63	3158	1.0	Reference
⩾1 year	4	29	5.0	(1.6 to 15.4)
Pesticides				
<1 year	65	3142	1.0	Reference
⩾1 year	2	45	1.9	(0.4 to 8.1)
Endotoxin				
<1 year	42	2311	1.0	Reference
⩾1 year	25	876	1.6	(0.9 to 2.6)

*Adjusted for age at baseline only.

(including cotton, wool, silk, total natural fibres, synthetic fibre, and mixed fibre) and to the 12 major chemicals (including solvents, bleaching agents, acids and bases, sulphuric acid, dyes, dye and dye intermediates, inks, resin monomers, formaldehyde, pesticides, and metals).

In addition, we obtained quantitative information on cotton dust and endotoxin exposures. Details of this assessment are reported elsewhere.[20] Briefly, quantitative assessment of the cotton dust exposure was estimated for each specific textile process using historical measurements collected by industrial hygienists from 56 factories between 1975 and 1999. Endotoxin concentrations were estimated using the predicted cotton dust estimates and average concentrations of endotoxin per unit dust mass (EU/mg dust) in each major process from the studies conducted by Christiani *et al*[21–23] and from additional data collected for this study.[20] These quantitative estimates were combined with each subject's work history and information from the JEM to estimate cumulative historical exposures of cotton dust and endotoxin. The assessment of exposure was made without knowledge of the women's disease status.

The study was approved by the Institutional Review Boards of the Fred Hutchinson Cancer Research Center and the Station for Prevention and Treatment of Cancer of the Shanghai Textile Industry Bureau, in accordance with an assurance filed with the Office for Human Research Protections (OHRP) of the US Department of Health and Human Services.

Analysis

We applied Cox proportional hazards modeling, adapted for the case cohort design, for risk analyses using STATA software. A weight of 1 was applied for all cases, and weights equal to the reciprocal of the sampling fractions were applied for all of the non-cases in the subcohort. The weighting was accounted for in the Cox regression by including the natural logarithm of the weight as an offset term in the model statement. In this way, an offset value of zero was assigned to all cancer cases because all cases have been sampled with the probability of one.[24] The measured association was the hazard ratio (HR) and its corresponding 95% confidence interval (CI). The likelihood ratio test was used to test for exposure-response associations. Risks associated with various textile manufacturing processes were estimated for ever (⩾1 year) versus never (<1 year) employed, and by duration of employment (0, >0 to <10 years, ⩾10 years) in each process. Risks associated with exposures to various dusts and chemical agents were estimated in the same manner. Cumulative exposures to cotton dust and endotoxin were categorised into quartiles according to the quartile distributions of subcohort members to estimate exposure-response gradients. We also evaluated risks in relation to various exposures with lag intervals of 10 years and 20 years to take into account latency effects.

RESULTS

The cancer cases were younger than the non-cases; therefore, all hazard ratio estimates for risk of NPC and sinonasal carcinoma presented were adjusted for age as a continuous variable. Smoking and alcohol use were not prevalent, and not significantly associated with risk of either NPC or sinonasal carcinoma, and thus were not found to be confounders of other associations (table 1).

A significant relation was found between risk of NPC and duration of work in the dyeing job category (table 2). An increased risk was observed among women who worked at printing jobs for less than 10 years, but not for more than 10 years, although the small number of cases that ever worked in printing limited statistical precision.

Women who were exposed to cotton dust or inks for more than one year had significantly increased risk of NPC (table 3). In addition, workers exposed to sulphuric acid had a ninefold increased risk, although this estimate was based on only one exposed case and five exposed controls (data not shown).

Significantly increased risks were observed for women who were exposed to dyes, inks, and cotton dust for less than 10 years, but not for those with longer exposures (table 4). Trends of NPC risk, of borderline statistical significance, were observed with duration of exposure to acids and bases, and to endotoxin. No cases and only 10 non-cases were exposed to formaldehyde.

The associations between risk of NPC and various exposures examined in tables 2 and 4 were re-examined with a lag of 10 and 20 years. No appreciable differences were observed.

Compared with women who have never been exposed to the cotton dust, women exposed to more than 143.4 mg/m^3 × years of cotton dust and more than 3530.6 EU/m^3 × years of endotoxin had 3.6 and 2.5-fold increased risks of NPC, respectively (table 5). The association remained similar when re-estimated with a lag of 10 and 20 years (data not shown).

We also investigated the associations between risk of sinonasal cancer and textile exposures (data not shown). Sinonasal cancer was associated with exposures >1 year to silk dust (HR = 5.1, 95% CI 1.1 to 24.3), benzene (HR = 27.7, 95% CI 3.0 to 256.8), and acid (HR = 26.6, 95% CI 2.9 to 242.3). However, these findings are based on only 10 cases

Table 4 Hazard ratio estimates of nasopharyngeal carcinoma in relation to the duration of occupational exposures classified by job exposure matrix

Exposure	Cases	Non-cases	HR*	95% CI	p for trend
Cotton dust					
Never	19	1232	1.0	Reference	
<10 years	12	292	2.7	(1.3 to 5.7)	
⩾10 years	36	1663	1.6	(0.9 to 2.9)	0.33
Wool dust					
Never	61	2737	1.0	Reference	
<10 years	1	94	0.5	(0.1 to 3.8)	
⩾10 years	5	356	0.7	(0.3 to 1.7)	0.29
Synthetic fibre dust					
Never	42	1922	1.0	Reference	
<10 years	6	238	1.1	(0.5 to 2.6)	
⩾10 years	19	1027	0.8	(0.5 to 1.4)	0.52
Solvents					
Never	52	2729	1.0	Reference	
<10 years	6	169	1.5	(0.6 to 3.6)	
⩾10 years	9	289	1.4	(0.7 to 2.8)	0.30
Bleaching agents					
Never	64	3141	1.0	Reference	
<10 years	1	16	2.0	(0.3 to 15.7)	
⩾10 years	2	30	2.6	(0.6 to 11.4)	0.20
Acids, bases, and caustics					
Never	55	2924	1.0	Reference	
<10 years	4	90	1.7	(0.6, 5.0)	
⩾10 years	8	173	2.1	(1.0, 4.6)	0.05
Dyes					
Never	62	3091	1.0	Reference	
<10 years	3	30	3.3	(1.0 to 11.5)	
⩾10 years	2	66	1.3	(0.3, 5.6)	0.32
Inks					
Never	63	3158	1.0	Reference	
<10 years	2	7	14.0	(2.6 to 74.0)	
⩾10 years	2	22	3.0	(0.7 to 14.0)	0.05
Endotoxin					
Never	41	2303	1.0	Reference	
<10 years	5	170	1.6	(0.6 to 4.1)	
⩾10 years	21	714	1.7	(1.0 to 2.9)	0.05

*Adjusted for age at baseline only.

total, and only two cases were exposed to silk dust, and only one case was exposed to benzene or acid. None of the 10 sinonasal cancer cases was exposed to cotton dust.

DISCUSSION

In this case cohort study of women workers in the Shanghai textile industry, we found increased risks of NPC associated with cotton dust, possibly endotoxin exposure, and work in printing and dyeing job categories.

There are several strengths to this study. It is the largest cohort study of incident NPC conducted to date that has focused on occupational exposures among female textile workers. Trained field staff collected detailed information on lifetime jobs in the textile industry for each woman. Experienced local industrial hygienists collected comprehensive information on production processes, workshops, and measurements of hazardous exposures since the establishment of each factory. A JEM developed by experienced industrial hygienists was applied to link each job a woman ever held in the textile industry to specific exposures.

The study also has several limitations. The World Health Organization has classified NPC into three histological types: keratinising squamous cell carcinoma (type 1), non-keratinising carcinoma (type 2), and undifferentiated carcinoma (type 3), and the aetiology of NPC may vary by different histological types.[7] The number of cases precluded analyses by the different histological types. Although there was the potential for confounding between job categories if women

Table 5 Hazard ratio estimates of nasopharyngeal carcinoma in relation to cumulative quantitative cotton dust and endotoxin exposures

Exposure	Cases	Non-cases	HR†	95% CI	p for trend
Cotton dust (mg/m^3 × years)					
None	16	1016	1.0	Reference	
>0 to 55.9	12	543	1.2	(0.6 to 2.5)	
>55.9 to 97.0	12	543	1.4	(0.6 to 2.9)	
>97.0 to 143.4	6	542	1.0	(0.4 to 2.5)	
>143.4	21	543	3.6	(1.8 to 7.2)	<0.001
Endotoxin (EU/m^3 × years)					
None	12	916	1.0	Reference	
>0 to 1517.4	17	531	2.1	(1.0 to 4.5)	
>1517.4 to 2430.0	9	530	1.3	(0.6 to 3.2)	
>2430.0 to 3530.6	7	531	1.2	(0.5 to 3.2)	
>3530.6	14	530	2.5	(1.1 to 5.4)	0.09

†Adjusted for age at baseline only.

Main messages

- Nasopharyngeal cancer (NPC) risk in women textile workers in Shanghai, China was associated with exposures to dyes, inks, acids, and cotton dusts, although exposure-response gradients were not always consistent, and statistical precision was limited in some instances.
- A stronger association was found for cotton dust than endotoxin.
- Formaldehyde was not related to NPC risk, although very few subjects were classified as exposed.
- An increased risk for sinonasal cancer was observed for exposure to silk dust.

Policy implications

- These findings indicate the importance of assessing potential occupational risk factors for nasopharyngeal and sinonasal cancers in textile industry and other cohorts with similar exposures.
- Further research on the carcinogenic potential of inks, dyes, cotton dust, silk dust, and endotoxin is warranted.

held several different textile industry jobs, there was relatively little mobility between sectors or factories before 1994. Moreover, women usually held the same job in the same factory for their entire working career. In view of the large number of exposures considered, we believe any conclusions based on our findings should be drawn with caution.

Consumption of preserved foods, such as salted fish[5 25 26] in childhood, has been reported to be a risk factor for NPC in high risk populations. This dietary habit is relatively common among Cantonese in the southern part of China, but is less common in Shanghai. It was reported that the increased risk associated with salted fish was strongest for non-keratinising or undifferentiated NPC.[3] In our cohort, 42 out of the 54 women for whom we have histological information were classified as squamous cell carcinoma. Also, there is no reason to suspect that eating habits were related to occupational exposures. Therefore, it is not likely that the associations that we observed were confounded by dietary habits. Yu *et al*[27] found that smoking more than 30 pack-years were associated with a twofold increased risk of NPC among ethnic Chinese. The prevalence of current or former smoking is low in our cohort (3%), and not found to be a confounder. Several studies in Chinese populations have examined the possible role of passive smoking on risk of NPC, although the results are inconsistent.[28 29] Given the moderate dose-response relation between active smoking and NPC, an association with passive smoking would be expected to be weak. Even if such an exposure did increase risk, it is not likely that it would be related to the woman's occupation; thus, passive smoking is also unlikely to be an explanation of the observed associations in this study.

An association of textile occupations in relation to oral and pharyngeal cancer has been observed in several cohort[12 30] and case control studies.[13] A study of death registrations for oral and pharyngeal cancers in men age 15–64 years in England and Wales in 1959–63 showed a 90% excess risk of death from oral and pharyngeal cancer in bleachers, dyers, and finishers in the textile industry.[30] To our knowledge, there has never been a report of an association between cotton dust exposure or working in dyeing and printing processes in the textile industry and risk of NPC.

Cotton dust is frequently contaminated with Gram negative bacteria that produce endotoxin. Enhanced immune surveillance due to endotoxin exposure has been hypothesised as the mechanism by which cotton dust may reduce risk of lung cancer.[31] Our observed increased risk of NPC with cotton dust, and more weakly with imputed endotoxin exposure, if confirmed by others, would suggest that mechanisms other than alteration in the immune system are operative. Cotton dust or endotoxin may therefore influence the risk of NPC through multiple mechanisms.

Printing and dyeing in other occupations have been associated with NPC, and with cancers of the lung, urinary bladder, and liver.[10 32–34] It is therefore possible that similar exposures in dyeing and printing processes in the textile industry enhance risk of NPC. Dyeing and printing processes involve use of various solvents, pigments, chemicals, and inks, some of which contain known or suspected carcinogens, such as benzidine, chromium, tetrachloroethylene, benzene, toluene, styrene, and various acids and bases.

Formaldehyde exposure has been linked to the increased risk of nasopharyngeal and nasal cancers by other studies.[2 7 8] Formaldehyde exposure is reported to be commonly present in finishing agents used in the textile industry.[14] In our study, only 10 of the subcohort women, and none of the NPC cases were classified as having been exposed to formaldehyde. The absence of an observed association with formaldehyde may be partly the result of exposure misclassification. There were no measurement data on historical formaldehyde exposures from government and factory inspection reports. It is also possible that the formaldehyde exposures in the Shanghai textile industry were too low to be causally related to NPC.

There is some evidence that prolonged exposure to sulphuric acid is associated with the increased risk of NPC.[14] A cluster of three workers who were diagnosed with NPC and who had prolonged exposure to sulphuric acid vapour has been reported.[35] Long term exposure to acids, especially sulphuric acid, among various occupational groups and subsequent development of cancers of the upper respiratory tract, such as laryngeal cancer, have also been reported.[36] The possible association observed in the present study was based on only one case of NPC that had ever been exposed to sulphuric acid for more than one year, and therefore requires independent confirmation.

Sinonasal cancer has also been related to work in the textile industry in several studies.[11 37] Luce *et al*[37] reported that exposure to textile dust was associated with a two to threefold excess risk of sinonasal cancer among women, and a pooled analysis of 12 case control studies reported a similar association. We found an increased risk of sinonasal carcinoma associated with exposure to silk dust, benzene, and acids. The limited numbers of exposed cases did not allow us to investigate possible exposure-response relations.

In summary, we observed that exposures to cotton dust, dyes, and inks, and possibly endotoxin, were associated with an increased risk of nasopharyngeal carcinoma. Exposures to acids and caustics, especially sulphuric acid, may also be associated with increased risk, although the findings are based on small numbers and need further investigation.

ACKNOWLEDGEMENTS

This research was supported by grant R01CA80180 from the US National Cancer Institute, National Institutes of Health, Department of Health and Human Services, and US National Institute of Environmental Health Sciences Training Grant ES07262 (to KJW).

We thank Drs Fan Liang Chen, Yong Wei Hu, Guan Lin Zhao, and Lei Dan Pan for their ongoing support of this cohort. We thank Wang Wen Wan, the interviewers, and six industry hygienists for their effort in collecting and coding data; and Georgia Green, Shirley Zhang, Richard Gandolfo, and Ted Grichuhin for their technical and administrative support.

Authors' affiliations

W Li, R M Ray, E D Fitzgibbons, Z Feng, D B Thomas, H Checkoway, Program in Epidemiology, Fred Hutchinson Cancer Research Center, Seattle, WA, USA
D L Gao, Department of Epidemiology, Zhong Shan Hospital Cancer Center, Shanghai, China
N S Seixas, J E Camp, K J Wernli, G Astrakianakis, Z Feng, D B Thomas, H Checkoway, School of Public Health and Community Medicine, University of Washington, Seattle, WA, USA

REFERENCES

1 **Hildesheim A**, Levine PH. Etiology of nasopharyngeal carcinoma: a review. *Epidemiol Rev* 1993;**15**:466–85.
2 **Parkin DM**, Muir CS, Whelan SL, *et al. Cancer incidence in five continents*, IARC Scientific Publications No 120. Lyon: International Agency for Research on Cancer, 1992;**6**.
3 **Yu MC**, Yuan JM. Epidemiology of nasopharyngeal carcinoma. *Semin Cancer Biol* 2002;**12**:421–9.
4 **Spano JP**, Busson P, Atlan D, *et al.* Nasopharyngeal carcinomas: an update. *Eur J Cancer* 2003;**39**:2121–35.
5 **Zheng YM**, Tuppin P, Hubert A, *et al.* Environmental and dietary risk factors for nasopharyngeal carcinoma: a case-control study in Zangwu County, Guangxi, China. *Br J Cancer* 1994;**69**:508–14.
6 **Vaughan TL**, Shapiro JA, Burt RD, *et al.* Nasopharyngeal cancer in a low-risk population: defining risk factors by histological type. *Cancer Epidemiol Biomarkers Prev* 1996;**5**:587–93.
7 **Vaughan TL**, Stewart PA, Teschke K, *et al.* Occupational exposure to formaldehyde and wood dust and nasopharyngeal carcinoma. *Occup Environ Med* 2000;**57**:376–84.
8 **Roush GC**, Walrath J, Stayner LT, *et al.* Nasopharyngeal cancer, sinonasal cancer, and occupations related to formaldehyde: a case-control study. *J Natl Cancer Inst* 1987;**79**:1221–4.
9 **Demers PA**. Boffetta P, Kogevinas M, *et al.* Pooled reanalysis of cancer mortality among five cohorts of workers in wood-related industries. *Scand J Work Environ Health* 1995;**21**:179–90.
10 **Liu YH**, Du CL, Lin CT, *et al.* Increased morbidity from nasopharyngeal carcinoma and chronic pharyngitis or sinusitis among workers at a newspaper printing company. *Occup Environ Med* 2002;**59**:18–22.
11 **Brinton LA**, Blot WJ, Fraumeni JF Jr. Nasal cancer in the textile and clothing industries. *Br J Ind Med* 1985;**42**:469–74.
12 **Delzell E**, Grufferman S. Cancer and other causes of death among female textile workers, 1976–78. *J Natl Cancer Inst* 1983;**71**:735–40.
13 **Olsen JH**. Jensen OM. Occupation and risk of cancer in Denmark. An analysis of 93,810 cancer cases, 1970–1979. *Scand J Work Environ Health* 1987;**13**(Suppl 1):1–91.
14 **IARC**. *IARC monographs on the evaluation of carcinogenic risks to humans*. Lyon: International Agency for Research on Cancer, 1992.
15 **Mastrangelo G**, Fedeli U, Fadda E, *et al.* Epidemiologic evidence of cancer risk in textile industry workers: a review and update. *Toxicol Ind Health* 2002;**18**:171–81.
16 **Thomas DB**, Gao DL, Self SG, *et al.* Randomized trial of breast self-examination in Shanghai: methodology and preliminary results. *J Natl Cancer Inst* 1997;**89**:355–65.
17 **Thomas DB**, Gao DL, Ray RM, *et al.* Randomized trial of breast self-examination in Shanghai: final results. *J Natl Cancer Inst* 2002;**94**:1445–57.
18 **Wernli KJ**, Ray RM, Gao DL, *et al.* Cancer among women textile workers in Shanghai, China: overall incidence patterns, 1989–1998. *Am J Ind Med* 2003;**44**:595–9.
19 **Borgan O**, Langholz B, Samuelsen SO, *et al.* Exposure stratified case-cohort designs. *Lifetime Data Anal* 2000;**6**:39–58.
20 **Astrakianakis G**. Cotton dust, endotoxin exposure and the risk of lung cancer among female textile workers in Shanghai. Doctoral Dissertation, University of Washington, 2005.
21 **Christiani DC**, Ye TT, Zhang S, *et al.* Cotton dust and endotoxin exposure and long-term decline in lung function: results of a longitudinal study. *Am J Ind Med* 1999;**35**:321–31.
22 **Christiani DC**, Ye TT, Wegman DH, *et al.* Cotton dust exposure, across-shift drop in FEV1, and five-year change in lung function. *Am J Respir Crit Care Med* 1994;**150**:1250–5.
23 **Olenchock SA**, Christiani DC, Mull JC, *et al.* Airborne endotoxin concentrations in various work areas within two cotton textile mills in the People's Republic of China. *Biomed Environ Sci* 1990;**3**:443–51.
24 **Barlow WE**, Ichikawa L, Rosner D, *et al.* Analysis of case-cohort designs. *J Clin Epidemiol* 1999;**52**:1165–72.
25 **Yu MC**, Ho JH, Lai SH. *et al.* Cantonese-style salted fish as a cause of nasopharyngeal carcinoma: report of a case-control study in Hong Kong, *Cancer Res*, 1986;**46**:956–61.
26 **Ning JP**, Yu MC, Wang QS, *et al.* Consumption of salted fish and other risk factors for nasopharyngeal carcinoma (NPC) in Tianjin, a low-risk region for NPC in the People's Republic of China. *J Natl Cancer Inst* 1990;**82**:291–6.
27 **Yu MC**, Garabrant DH, Huang TB, *et al.* Occupational and other non-dietary risk factors for nasopharyngeal carcinoma in Guangzhou, China. *Int J Cancer* 1990;**45**:1033–9.
28 **Yuan JM**, Wang XL, Xiang YB, *et al.* Non-dietary risk factors for nasopharyngeal carcinoma in Shanghai, China. *Int J Cancer* 2000;**85**:364–9.
29 **Cheng YJ**, Hildesheim A, Hsu MM, *et al.* Cigarette smoking, alcohol consumption and risk of nasopharyngeal carcinoma in Taiwan. *Cancer Causes Control* 1999;**10**:201–7.
30 **Moss E**, Lee WR. Occurrence of oral and pharyngeal cancers in textile workers. *Br J Ind Med* 1974;**31**:224–32.
31 **Enterline PE**, Sykora JL, Keleti G, *et al.* Endotoxins, cotton dust, and cancer. *Lancet* 1985;**2**:934–5.
32 **Lynge E**, Rix BA, Villadsen E, *et al.* Cancer in printing workers in Denmark. *Occup Environ Med* 1995;**52**:738–44.
33 **Moss E**, Scott TS, Atherley GR. Mortality of newspaper workers from lung cancer and bronchitis 1952–66. *Br J Ind Med* 1972;**29**:1–14.
34 **Leon DA**. Mortality in the British printing industry: a historical cohort study of trade union members in Manchester. *Occup Environ Med* 1994;**51**:79–86.
35 **Ho CK**, Lo WC, Huang PH, *et al.* Suspected nasopharyngeal carcinoma in three workers with long-term exposure to sulphuric acid vapour. *Occup Environ Med* 1999;**56**:426–8.
36 **Steenland K**, Schnorr T, Beaumont J, *et al.* Incidence of laryngeal cancer and exposure to acid mists. *Br J Ind Med* 1988;**45**:766–76.
37 **Luce D**, Gerin M, Morcet JF, *et al.* Sinonasal cancer and occupational exposure to textile dust. *Am J Ind Med* 1997;**32**:205–10.