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Preliminary analysis of proportional mortality in a cohort of British pottery workers exposed to crystalline silica

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A cohort of 7020 male pottery workers born in 1916—1945 was identified from all employees in dust-exposed trades, subject to medical surveillance by the Benefits Agency Medical Service of the Department of Social Security in Stoke-on-Trent in the United Kingdom. All but 256 (3.6%) were traced, 1016 (15.0%) had died by 30 June 1992, and death certificates were obtained for 940 (92.5%) of the fatalities — 122 from respiratory cancer. After the exclusion of any recorded asbestos exposure, the proportional mortality ratio (PMR) for lung cancer was 1.22 when calculated against national rates ($P < 0.02$), but the PMR against local rates was 1.04. Logistic regression analyses based on 75 nested case-referent pairs for which the required information was available showed that lung cancer mortality was dominated by smoking and significantly affected by past asbestos exposure. However, for 47 pairs in which both the case and referent had a history of smoking, there was also significant evidence that the risk was related to duration of silica dust exposure in pottery work but not to radiological score.

Key terms lung cancer, pottery, British workers.

The British pottery and ceramics industry has, for centuries, been centered in the "five towns" of Staffordshire, of which Stoke-on-Trent is the largest. Products include a wide range of sanitary and domestic ware and materials for industrial use, all entailing potential exposure for the worker to airborne respirable dust with high crystalline silica content. Most of the manufacturing processes include heat treatment at some stage in ovens at temperatures sometimes in excess of 1500°C, with probable conversion of a proportion of the quartz component to tridymite and cristobalite. Although there is little exposure to potential respiratory carcinogens other than silica in the industry, some employees are known to have worked previously in foundries, coal mines, and asbestos-related trades. Dust control in the industry was limited before 1945, but since then has been considerably more effective. During World War II production was greatly reduced.

Preliminary findings on lung cancer mortality from a follow-up of a stratified sample of the current work force of the British pottery industry, included in a survey in 1970—1971, were published by Winter et al (1). The latter investigators had some difficulty in ensuring a complete follow-up and confined their report to the mortality experience of 3669 men under 60 years of age. In this cohort 60 deaths from lung cancer were observed against 42.8 expected from national rates [standardized mortality ratio (SMR) 1.40, $P = 0.007$] and 45.6 from locally adjusted rates (SMR 1.32, $P = 0.023$).

The study on which the present preliminary report was based was initiated after discussion with those responsible for the earlier investigation. Our general approach differed in that it followed the more usual procedure of defining the cohort as subjects at the time of first exposure and in terms of date of birth. Whereas the earlier study covered pottery workers in all parts of the United Kingdom, the present cohort was recruited entirely from refractory, sandstone, and pottery workers subject to health surveillance at Stoke-on-Trent. It is likely that the two cohorts had some members in common.

Subjects and methods

The cohort. From 1931 to 1984, when the legislation was revoked, employers in the United Kingdom were required to notify the silicosis medical boards and their successors of any employee who was to work in specific dust-exposed trades and processes. At the Department of Social Security Boarding Centre, Stoke-on-Trent, those notified are entered into a card register, which is maintained indefinitely. They are then subject to an initial medical examination and further periodic examinations every two years, including full-size chest radiographs (posteroanterior) taken when first seen and every four years thereafter. A standard medical record form, which has changed somewhat over the years, is completed by the physician at each visit and contains the following information: full name, gender, date of birth, national insurance number, job or process for which employed, history with duration of any previous dust-exposed work (eg, coal, asbestos, foundries, quarries, etc), smoking habits, and classification of chest radiograph according to the system of the International Labour Organisation (ILO).

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Table 1. Proportional mortality ratios (PMR) for lung cancer in the cohort and its subcategories, 1961—1992. (90%CI = 90% confidence interval)

	Lung cancer		PMR	90% CI	P-value[a]
	Observed	Expected			
All deaths (N = 940)	122	98.69	1.24	1.06—1.44	0.009
Excluding known asbestos exposure (N = 877)	112	91.61	1.22	1.04—1.43	0.017
Excluding pneumoconiosis on death certificate (N = 899)	115	93.64	1.23	1.05—1.44	0.014
With pneumoconiosis on death certificate (N = 30)	7	4.00	1.75	0.70—3.60	0.111

[a] One-tailed.

Table 2. Distribution of the variables used in the nested case-referent analysis of 75 matched pairs. (ILO = International Labour Organisation)

Variables	Cases (N)	Referents (N)
Smoking		
Nonsmokers	1	17
Current smokers	53	35
Ex-smokers	12	17
Not known	9	6
Exposure (years)		
< 3	23	20
3—4	9	7
5—9	7	15
10—19	12	9
≥ 20	24	24
Small opacities (ILO)		
0/0	69	71
0/1	3	1
1/0—1/2	1	2
≥ 2/1	2	1
Previous asbestos work		
Recorded	11	5
Not recorded	64	70

These records are supposedly destroyed 10 years after last employment under the regulations and not later than at the age of 70 years, but in fact these rules have not been rigorously applied. The records are also destroyed after two years if the center is informed of the subject's death; however, no special steps are taken to learn of these deaths.

Our cohort was defined from the card register as all men born in 1916—1945, with full name, national insurance number, and date of birth for identification and tracing. It numbered 7020.

Ascertainment of deaths and cause of death. Identifying information on the 7020 members of the cohort was given to the Department of Social Security with the request that their vital status be established as of 30 June 1992. Through matching against the Department's central register all but 256 men (3.6%) were traced satisfactorily, in most cases exactly. Of this total, 5748 were reported to be alive, and 1016 (15.0%) were dead.

Information on deaths was then passed to the Office of Population, Censuses and Statistics so that the certified cause of death could be obtained from the National Health Service Central Register. The fact and date of death were confirmed and copies of death certificates were obtained for 940 (92.5%) of the 1016 fatalities. Of these 940 deaths, 122 were ascribed to respiratory cancer (code 162 of the International Classification of Diseases). Pneumoconiosis was recorded on the death certificates as the primary cause in 11 cases and as a contributing cause in 30 cases. This proportion (1.2%) is similar to the 1.0% observed for chrystotile miners and millers (2).

Dust exposure. Extensive records exist for airborne dust concentrations, recorded since the late 1960s in various parts of the industry. These measurements were made gravimetrically on respirable dust with a personal sampler and fell in the range of 0—800 $\mu g \cdot m^{-3}$ (mostly between 100 and 200). Records were increasingly sparse for earlier years, but some related to the 1930s and even earlier. The earlier measurements were mainly dust particle counts made with impinger methods and static samplers. Work is proceeding on these data for use in later exposure-response analyses of mortality and radiographic findings.

Results

Proportional mortality. A series of analyses was made in which the numbers of cases of lung cancer in the cohort were compared with the numbers expected from the proportion of deaths from this cause in England and Wales, 1961—1992, standardized for the quinquennium of birth and age at death. In these and other analyses 90% confidence intervals (90% CI) were calculated, as were probabilities based on a one-tailed distribution of the chi-square. The results are tabulated in table 1.

Overall, even after any recorded asbestos exposure was excluded, the proportional mortality ratio (PMR) for lung cancer (1.22) was significantly raised ($P < 0.02$). The lung cancer PMR for deaths with mention of pneumoconiosis was 1.75, and the risk was higher than for that without (1.23), but with overlapping confidence intervals. However, 70% of the deaths in the cohort were from Stoke-on-Trent, where there is a high mortality from all causes (standardized mortality ratio 1.20), especially for lung cancer (standardized mortality ratio 1.43). The PMR for lung cancer in Stoke-on-Trent during 1979—1983 was 1.17; when the PMR for our cohort was expressed relative to this figure, we obtained an estimated PMR of 1.04.

Nested case-referent study. To assess the effect of smoking habits, duration of occupational dust exposure, previous work with asbestos, and the ILO score for small opacities in the most recently recorded chest radiograph, we analyzed matched pairs by logistic regression. The study was restricted to 75 lung cancer cases and referents for which the X-ray reading was available. The referents for each pair were selected by a random process from cohort members who survived the case matched for date of birth (± 3 years) and date of first dust exposure (± 3 years). The crude distribution of the relevant variables, set out in table 2, showed a similarity in durations of exposure and previous work with asbestos, a relative rarity of X-ray changes, but a substantial difference in smoking

habits. For the latter reason the regression analysis was made first with all 75 pairs and then with 47 pairs for which both the case and the referent had a history of cigarette smoking. Table 3 shows the results of these analyses (with 90% confidence intervals) and demonstrates a significant effect of past asbestos work [odds ratio (OR) 3.3 and 3.8]. For the smoking pairs the results showed an effect of duration of dust exposure in pottery work (OR 2.8), but gave no suggestion that the risk was associated with radiological score (OR 0.9 and 0.8).

Table 3. Results from the logistic regression analyses of matched case-referent pairs (OR = odds ratio, 90% CI = 90% confidence interval)

	All pairs (N = 75)		Smoking pairs (N = 47)	
	OR	90% CI	OR	90% CI
Asbestos exposure	3.3	1.1—10.2	3.8	1.1—12.8
Silica exposure (≥ 10 years)	1.4	0.7—2.7	2.8	1.1—7.5
Small opacities	0.9	0.2—3.7	0.8	0.2—3.6

Concluding remarks

It must be emphasized again that the findings in this report are preliminary. Work in progress will correct the deficiencies in the tracing and ascertainment of cause of death and will allow exposures to be assessed both in duration and estimated concentrations of crystalline silica. Although most exposures to crystalline silica experienced by the cohort members were seldom more than about 200 $\mu g \cdot m^{-3}$, some 150 of the 7020 men are known to have had small opacity scores of 1/0 and above. It will therefore be possible to examine the validity of our work histories and exposure estimates before eventually making more-detailed analyses of mortality by both person-years and case-referent methods.

From the present results it is evident that lung cancer mortality is dominated in this cohort by smoking, with, at most, only weak evidence of any excess attributable to work exposure. Much will depend on detailed analyses of exposure response (3). The high prevalence level of lung cancer mortality in Stoke-on-Trent makes any comparisons against national or local area statistics difficult to interpret. A person-years analysis restricted to 470 deaths from January 1985 to June 1992 gave a lung cancer SMR of 1.28 when calculated against local rates (68 observed, 53.1 expected, 90% CI 1.04—1.57) (3).

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