Lung cancer among newspaper printers exposed to ink mist: a study of trade union members in Manchester, England

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Abstract
A nested case-control study of lung cancer among men exposed to ink mist in newspaper production with rotary letterpress technology is presented. It is based within a historical cohort of 9232 printing workers in Manchester (1949-63). Men who operated newspaper rotary letterpress machines had a lung cancer standardised mortality ratio (SMR) of 179 (95% confidence interval (95% CI) 144-218) when compared with rates for England and Wales for the follow up period 1950-83. When adjustment was made for the higher rates in the local area, the SMR was reduced to 122 (95% CI 98-148). The nested case control study was based on 110 lung cancer cases (1949-86) and 316 matched controls. Duration of work in a rotary letterpress machine room was positively associated with risk of lung cancer ($\chi^2$ linear trend = 3.30, $p = 0.07$); men with 30 or more years duration of exposure had a risk of 1.73 (95% CI 0.94-3.17), relative to those with less than 20 years of exposure. Adjustment for period of first exposure in a machine room reduced the strength of the positive duration effect. The magnitude of the SMRs found in the cohort study could be explained by confounding with smoking. The duration effect seen in the case-control study, however, suggests that there may be a real effect of exposure to letterpress ink mists. This is biologically plausible, as benzen[a]pyrene, a known human carcinogen, has been found in appreciable concentrations in the atmosphere of rotary letterpress machine rooms.

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For most of this century until the late 1980s, large scale newspaper production in Britain and other countries was mainly carried out with rotary letterpress printing machines. This process used inks based on mineral oils pigmented with carbon black. The high speed rotation of the presses tended to result in the production of ink particles and paper dust that were projected into the pressroom atmosphere as a fine mist, a proportion of which was of respirable size. The carcinogenic potential of letterpress inks has been difficult to assess. There is uncertainty about the carcinogenicity of carbon black on its own in animals and humans. Solvent extracts of carbon black have, however, been shown to cause cancer in animals. This may be due to polycyclic aromatic hydrocarbons, such as the known carcinogen benzo[a]pyrene, that are adsorbed on to the surface of the carbon black particles and have been shown to be present in the atmosphere of newspaper letterpress machine rooms.

Some direct evidence exists concerning risk of lung cancer among newspaper printers who would have been exposed to ink mist. Two cohort studies from the United States and a proportional mortality study of newspaper pressmen in Great Britain found the number of deaths from lung cancer to be 50% or more in excess of that expected. Another proportional mortality study from the United States failed to find evidence of an excess.

In 1980 a historical cohort study of print workers in Manchester was set up to investigate whether they had an increased risk of death, particularly from cancer, compared with the general population. This study suggested that newspaper pressmen working with rotary letterpress machines may have had an increased occupational risk of lung cancer. This finding, together with the other positive evidence made it important to investigate this issue further. There were limits, however, to what could be achieved with the cohort data, as its reliable exposure information was principally limited to occupation on entry to each union. A more in depth study required information on complete occupational histories, including place and duration of work in particular occupations. The collection of the necessary additional information was most efficiently done by conducting a case-control study based within the cohort, as we describe here.

Subjects and methods
COHORT STUDY
The background to and the design of the Manchester cohort study of printing workers have been described elsewhere. In summary, over 9500 men who were trade union members between 1949 and 1963 formed the basis of a historical cohort constructed from the membership records of the Manchester branches of two printing trade unions—the National Graphical Association (NGA) and the National Society of Operative Printers, Graphical, and Media Personnel (NATSOPA). The NGA was the craft union
of the industry. In Manchester its members worked in all sections of the printing industry, although only a few were employed in newspaper production. By contrast, NATSOPA membership was concentrated in newspaper production, covering a broad range of occupations from commissionaires and cleaners to machine assistants who operated newspaper rotary letterpress machines, and were exposed to ink mist.

The cohort analyses concentrated on the 9232 men born in 1890 or later, and their mortality from 1950–83, during which period 3482 deaths occurred. Follow up was 97% complete. Comparisons were made of cohort mortality with those of the male population of England and Wales with indirect standardisation for age and calendar period, with and without adjustment for the generally higher mortality in the Manchester area. Where appropriate direct comparisons were made of mortality within the cohort by modelling death rates with the Poisson regression in GLIM.13

NESTED CASE–CONTROL STUDY

The case-control analyses were based on NATSOPA members of the cohort born in 1890 or later, who at some point during their branch membership had been machine assistants. Machine assistants were the largest of the NATSOPA occupational groups; 1322 men entered the branch in this category, and a further 635 entered the branch in another occupation and subsequently became machine assistants. NGA men were not included in the case-control study as a much smaller number of them were involved in newspaper printing, and there was limited information available from branch records concerning detailed histories of membership.

Cases of lung cancer were identified from among deaths of NATSOPA machine assistants that met certain criteria. Firstly, their only known work in the industry was as a member of the Manchester NATSOPA branch. This exclusion was to avoid the difficulty of determining the type or extent of exposures that occurred outside the branch. Secondly, they entered the Manchester branch in 1915 or later. This criterion was imposed as it was judged that earlier exposures would be of little current relevance. Thirdly, to be a case, lung cancer had to be specified as the underlying cause or mentioned on the death certificate in the period 1949–86. The International Classification of Disease (ICD) codes used to define lung cancer were 1620–1628 or 1630–1639 for the 6th and 7th revisions of the classification and 1620–1629 for the 8th and 9th revisions. The extension to the definition of lung cancer to include mentions (of which there were five) and the wider calendar period compared to that used in the cohort study was adopted to increase the power of the study.

For each case, attempts were made to select five controls at random from all other machine assistants in the cohort study who met the general criteria outlined above at the date of death of their matched case. Additionally controls had to be born within 2-5 years of their corresponding case and be at risk of dying in the study on the date of death of the case. Subject to these constraints a case could be a control for an earlier occurring case. For only two cases were fewer than five controls identified. The first three controls selected for each case were taken forward to the data collection stage, the additional controls being held in reserve in case any of the original controls proved to be ineligible for inclusion.

Case and control identification details, including name, date of birth, and branch membership number, were abstracted from the cohort study data. A complete occupational history for each individual in the study, from their date of entry to the Manchester branch to the end of 1988, was then compiled from the NATSOPA branch records. This information was collected by people who were blind to the case or control status of study subjects. At this stage a few cases and controls were found not to meet the selection criteria and were excluded, principally because no details of work as machine assistants could be traced.

The occupational histories took the form of dates of entry to and exit from chapels in the NATSOPA branch. A chapel was an organisational subunit of the branch structure that could have several hundred members. A newspaper chapel in Manchester would be specific both to a particular newspaper plant and an occupational group. The chapel records were held centrally by the branch, and were essentially complete as they were used to note dues contributions of each member on a weekly basis.

Three controls per case were considered adequate for the analysis. After the mentioned exclusions, there remained 110 cases and 316 controls. Of the 110 matched sets, 97 had three controls, 12 had two controls, and one had one control.

Duration of chapel membership was taken as an indication of duration of work in the printing industry, due to the known link to risk. For control records, the equivalent duration of work was calculated only up to the date of death of the case to which they were matched. This, together with the fact that controls were sampled from contemporaneous risk sets means that the odds ratios estimated in the case-control study are direct and unbiased estimates of the lung cancer rate ratio.14

If work in newspaper machine rooms did increase risk of lung cancer, then this effect is unlikely to be immediate but would manifest itself only after a latent period of 15 or 20 years from the time of first entry. To take account of this, analyses were undertaken that excluded all cases dying within 15 years of first entry, and all controls whose date of first entry was less than 15 years before the date of death of their matched case. It should be noted that these latent period analyses have reduced power, as they are based on only 93 matched sets. Of these, 69 had three
controls, 23 had two controls, and one had one control.

Conditional logistic regression\textsuperscript{13} was used to estimate the independent effects on lung cancer death rates of duration of membership of chapels that involved work in newspaper machine rooms and period of first entry to such chapels. This was done with the EGRET computer package.\textsuperscript{14} Whether an explanatory factor had an effect on the rate ratio that was independent of any particular set of other variables was judged by comparing the fit of the regression models with and without terms for the factor. The difference in the fit of the two models was tested with a heterogeneity statistic that could be referred to the $\chi^2$ distribution on k-1 degrees of freedom, where k was the number of levels of the factor. Where appropriate, models were also fitted that treated duration of membership as a continuous scored variable.

**Results**

**COHORT STUDY**

Men who entered the Manchester NATSOPA branch as machine assistants had a lung cancer standardised mortality ratio (SMR) of 179 (95% confidence interval (95% CI) 144–218) when compared with rates for England and Wales, and an SMR of 122 (95% CI 98–148) when also adjusted for the higher rates in the Manchester area. The equivalent SMRs for bronchitis, based on 55 deaths, were 152 (95% CI 114–196) for comparisons with England and Wales and 103 (95% CI 77–132) adjusted for the Manchester effect. Internal comparisons of mortality within the cohort showed that only one of the 16 occupational categories in the study had a higher lung cancer mortality than machine assistants, whereas three had higher mortality from bronchitis.

One further result from the cohort study should be noted; NGA rotary machine managers, although far less numerous, worked alongside the NATSOPA machine assistants, and were thus exposed to the same work environment. Compared with rates in England and Wales, NGA rotary machine managers had a lung cancer SMR of 141 (95% CI 79–233), which was reduced to an SMR of 99 (95% CI 55–163) on adjustment for the Manchester effect. The equivalent SMRs for bronchitis, based on five deaths, were 55 (95% CI 18–127) and 38 (95% CI 12–88). In a direct comparison, NGA rotary machine managers had a lung cancer SMR that was 0·78 of that for NATSOPA machine assistants (95% CI 0·45–1·35), although they had the second highest SMR of any of the NGA occupational groups. By contrast, NGA rotary managers had the lowest rate for bronchitis of any of the NGA or NATSOPA occupational groups, with a rate ratio relative to NATSOPA machine assistants of 0·36 (95% CI 0·15–0·91).

**NESTED CASE-CONTROL STUDY**

Table 1 shows the distributions of the included cases by period and age at death. Table 2 shows the distributions of the included cases and their matched controls by various factors. As cases and controls were matched on birth year, they show a virtually identical distribution.

**Duration of membership of chapels involving work in machine rooms** (an indication of duration of work and exposure in newspaper machine rooms) is one of the main factors of interest in this study. From table 2 it is apparent that the cases are distributed more towards the longer duration categories than are the controls, which suggests that risk increases with duration. Similarly, the distribution of cases and controls by period of first exposure (table 2) suggests that men entering after 1930 may be at less risk than those entering exposure earlier.

Duration of membership, however, is related to when a person first entered a chapel involving work in a newspaper machine room. Long durations are associated with first entry a long time in the past, whereas short durations are associated with more recent first entry. Any real effects of duration or period of entry are therefore going to be mutually confounded.

Table 3 shows the conditional logistic regression estimates for the effects of duration, and table 4 shows those for period of first entry. The first column of each table shows the unadjusted, crude effects, the second column the mutually adjusted effects of duration and period of first entry, and the third column the adjusted effects, having allowed for a latent period of 15 years.

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**Table 1 Distribution of cases by year and age at death**

<table>
<thead>
<tr>
<th>Year of death</th>
<th>Cases (%)</th>
<th>No (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1949–58</td>
<td>10 (9·1)</td>
<td>100</td>
</tr>
<tr>
<td>1959–68</td>
<td>36 (32·7)</td>
<td>100</td>
</tr>
<tr>
<td>1969–78</td>
<td>35 (31·8)</td>
<td>100</td>
</tr>
<tr>
<td>1979–86</td>
<td>29 (26·4)</td>
<td>100</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Age at death (y)</th>
<th>Cases (%)</th>
<th>No (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20–29</td>
<td>2 (1·8)</td>
<td>110 (100·0)</td>
</tr>
<tr>
<td>40–49</td>
<td>5 (4·5)</td>
<td></td>
</tr>
<tr>
<td>50–59</td>
<td>26 (23·6)</td>
<td></td>
</tr>
<tr>
<td>60–69</td>
<td>49 (44·5)</td>
<td></td>
</tr>
<tr>
<td>70–79</td>
<td>24 (21·8)</td>
<td></td>
</tr>
<tr>
<td>80–99</td>
<td>4 (3·6)</td>
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</tbody>
</table>

**Table 2 Distribution of cases and controls by various factors**

<table>
<thead>
<tr>
<th>Year of birth</th>
<th>Cases (%)</th>
<th>Controls (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1890–99</td>
<td>29 (26·4)</td>
<td>76 (24·1)</td>
</tr>
<tr>
<td>1900–09</td>
<td>37 (33·9)</td>
<td>107 (33·9)</td>
</tr>
<tr>
<td>1910–19</td>
<td>86 (27·2)</td>
<td>223 (72·8)</td>
</tr>
<tr>
<td>1920–29</td>
<td>42 (13·5)</td>
<td>316 (96·5)</td>
</tr>
<tr>
<td>1930–39</td>
<td>5 (1·6)</td>
<td>120 (37·9)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Duration of exposure* (y)</th>
<th>Cases (%)</th>
<th>Controls (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 10</td>
<td>41 (13·0)</td>
<td>130 (40·0)</td>
</tr>
<tr>
<td>10–19</td>
<td>67 (21·2)</td>
<td>309 (90·8)</td>
</tr>
<tr>
<td>20–29</td>
<td>83 (26·3)</td>
<td>316 (96·5)</td>
</tr>
<tr>
<td>30–39</td>
<td>29 (9·2)</td>
<td>316 (96·5)</td>
</tr>
<tr>
<td>40–49</td>
<td>38 (12·0)</td>
<td>316 (96·5)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Period of entry to exposure†</th>
<th>Cases (%)</th>
<th>Controls (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1915–26</td>
<td>54 (17·1)</td>
<td>316 (96·5)</td>
</tr>
<tr>
<td>1927–30</td>
<td>54 (17·1)</td>
<td>316 (96·5)</td>
</tr>
<tr>
<td>1939–57</td>
<td>62 (19·6)</td>
<td>316 (96·5)</td>
</tr>
<tr>
<td>1958 +</td>
<td>55 (17·3)</td>
<td>316 (96·5)</td>
</tr>
</tbody>
</table>

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*Duration of exposure measured as period of membership of chapel(s) that involved work in newspaper machine rooms.
†Period of entry to exposure taken as period of first entry to a chapel that involved work in a newspaper machine room. Categories defined so that each contains about 20% of cases.
In table 3 the crude effects of duration show a clear contrast between the rate in those with 30 or more years of exposure compared with those with shorter durations, the largest rate ratio being in the longest duration category. The scored linear trend statistic is just below 5% statistical significance. After adjustment for period of entry, there remains the suggestion that mortalities increase with duration of membership, although the longest duration category (≥40 years) no longer has the highest rate ratio. The 95% CIs around each estimate are very wide.

Allowing for a 15 year latent period results in a much weaker suggestion of increasing risk with increasing duration. In this analysis, however, the reference category of <10 years is based on only four matched sets. When <20 years duration is used as an alternative baseline category, and the two longest duration categories are combined, the rate ratio for 20–29 years is 1.61 (95% CI 0.75–3.45) and for ≥30 years is 1.86 (95% CI 0.67–5.12). With the same aggregated duration categories, the corresponding adjusted rate ratios without allowance for a latent period are 1.28 (95% CI 0.65–2.55) for 20–29 years and 1.82 (95% CI 0.75–5.31) for ≥30 years. The linear trend statistics for both aggregated duration period analyses have p values of 0.2 or greater.

In table 4 the crude effects of period of first entry suggest that death rates are lower for men first entering after 1926, compared with earlier. Particularly striking is the rate ratio of 0.38 for those entering between 1931 and 1948, which has 95% CIs that exclude 1.00. Adjustment for duration of membership makes the effect of period of first entry less pronounced. Those entering in the period 1931–48 still have the lowest rate ratio, although for this period the 95% CI no longer excludes 1.00. After allowing for a latent period of 15 years, essentially the same pattern is seen as in the rate ratios unadjusted for duration of membership.

**Discussion**

The cohort study found clear evidence of excess mortality from lung cancer and bronchitis among NATSOPA machine assistants when compared with rates in England and Wales. Adjustment for the higher mortality from both these causes in the Manchester area substantially reduced these excesses. Nevertheless, compared with other occupational groups in the study, NATSOPA machine assistants had high mortality from both these causes. The evidence that mortality from both lung cancer and bronchitis is atypical, suggests that tobacco smoking may be an important confounding factor. It is striking, however, that the NSA rotary machine managers, who worked alongside the NATSOPA machine assistants, had raised lung cancer mortality compared with other NSA groups, but had the lowest mortality from bronchitis of any occupational group in the study. This picture is less consistent with a secondary effect through confounding with smoking.

The case-control results suggest that duration of work in newspaper machine rooms is related to risk of lung cancer, even when account is taken of period of first entry. The complementary analyses for period of first entry failed to show any clear pattern, although men entering between 1931 and 1948 seem to have the lowest risk.
Because of the strong correlation between period of first entry and duration of exposure, there is insufficient data on which to determine whether a dose-response effect exists for men entering the industry both before and after the second world war. As a consequence it is not possible to say whether any lung cancer problem that did exist occurred only among those exposed to conditions in the pre-war period.

SMOKING
Tobacco smoking has to be considered as a likely alternative explanation for the excesses of lung cancer reported in the cohort study. Ideally, the Manchester cohort and case-control studies should have taken smoking habits into account. Unfortunately, the information required to do this directly would have been virtually impossible to collect, as the smoking histories could not have been reliably obtained for many of the study members particularly those who had left the branch, and in many cases had died.

Data collected by the General Household Survey in 1972\(^1\) showed that workers in the paper and printing industry smoked only slightly more than the national average. Similar results were obtained in a special survey of the working membership of the Manchester branches of the NGA and SOGAT 82 (previously the Manchester branch of NATSOPA). The survey was undertaken in 1985 after preliminary analyses of the Manchester cohort study. A random sample was taken of 1000 men working in machine rooms, publishing rooms, and as compositors in Manchester newspaper plants. Self administered questionnaires were sent out and collected in by union officials at the local level. Only 62% of the questionnaires were returned, making it difficult to reach any reliable conclusions concerning the smoking habits of the target population.

The potential contribution of smoking to the increased mortality from lung cancer is put into perspective by empirical studies\(^18\-20\) that describe the range of effects that smoking may have on estimates of mortality in a wide range of occupations. In summary, these studies have compared the mortality from a selection of causes for a large number of occupations before and after adjustment for smoking. They conclude that rate ratios of greater than 1.4 for lung cancer are unlikely to be due to differences in smoking habits alone. From this perspective, the lung cancer SMR of 179 for NATSOPA machine assistants, based on England and Wales rates, is unlikely to be explained by smoking differences. On the other hand, the SMR of 122 based on national rates adjusted for the effect of the Manchester area could more plausibly be explained by differences in smoking habits between the study population and the population of Manchester area. The scope for this is more limited as part of any confounding effect by smoking has been removed precisely by the use of local rates as the standard.

Perhaps the strongest evidence against tobacco smoking being entirely responsible for the excess of lung cancer is the suggestion in the case-control study that risk of lung cancer increases with duration of work as a machine assistant. It is difficult to see how confounding with smoking could easily produce this effect. This is particularly so as within each case-control set, cases and controls were members of the same birth cohort and controls had had the opportunity to smoke for at least as long as the cases.

INK MIST
Since they were first introduced, the basic composition of black newspaper inks used on rotary letterpress machines has remained essentially the same. They are made up of mineral oil pigmented with carbon black. The ink dries by the oil penetrating into the paper to leave a stiff pigment paste on the surface.\(^1\) A typical formulation by weight would be 12% carbon black, 85% mineral oil, and 3% indoline dye toner, the last to give the ink a blue tone.\(^2\)

Direct skin contact with printing inks can occur when printing plates and other parts of the press are handled or cleaned. A much more serious and intractable problem is that of ink mist or “fly”,\(^2\) that is carried to all areas of a machine room when the presses are running. In the United States pressmen traditionally wore white paper hats to protect their hair from it.\(^2\) Men working in machine rooms have reported black nasal discharges.\(^4\-22\) Attempts to deal with the problem have been various, and include the addition of gelling agents to the inks to make them less liable to form droplets and electrostatic and mechanical extraction equipment mounted on the press. Despite these various approaches, it has proved difficult to eliminate the problem entirely.\(^2\)

The atmosphere in newspaper rotary letterpress machine rooms has been investigated in a number of studies. In a comparison of concentrations of mineral oil mists in different industries in the United States in the 1960s,\(^4\) newspaper machine rooms were found to have oil mist concentrations in the range 2.0-16.6 mg/m\(^3\). Ink mist concentrations in the pressroom of the New York Times in 1969\(^3\) were in the range 2.08-6.75 mg/m\(^3\) when the presses were running and without the exhaust system in operation, and in the range 2.59-3.43 mg/m\(^3\) with the exhaust system in operation. In the immediate vicinity of a bank of modern enclosed presses, concentrations during operation were as high as 28.5 mg/m\(^3\) (average 12.2 mg/m\(^3\)). The respirable fraction of this mist, measured in terms of mass, was estimated to be in the range 7% to 26% with an average of 15%. Interestingly, the ink mist concentrations found in the vicinity of older mainly unenclosed presses was slightly lower than detected near modern ones. This difference was explained by the higher operating speed of the modern presses.

In a survey of ink mist in nine London and three Manchester newspaper pressrooms conducted in 1978,\(^4\) the total airborne particulate...
matter (mainly ink mist but also paper dust) varied between plants in the range 0-01–2-87 mg/m\(^3\). The size distribution of the particles showed that about half of the mass fell outside of the respirable size range. A 1981 survey of conditions in the pressroom of the Financial Times, London,\(^6\) reported ink mist concentrations in the range of 0-22–0-51 mg/m\(^3\).

Consistent with the view within the industry, these studies suggest that since the 1960s there has been a reduction in the concentration of ink mist in newspaper pressrooms. For the Manchester cohort study, however, much of the relevant exposure would have occurred in the decades preceding any objective measurements of concentrations of ink mist. What therefore can be said about conditions in these earlier years? Press speed is a key factor in the production of ink mist. To this extent, the modern high speed presses have a greater tendency to produce ink mists than the older, slower designs.\(^3\) Set against this, however, is the fact that in the past there was no physical enclosure of press units, exhaust ventilation systems were crude or non-existent, and inks were not formulated to minimise their tendency to mist.

**BIOLOGICAL EFFECTS OF INKS**

In a review of the toxicology of chemicals used in the printing industry,\(^25\) it was considered that there was sufficient evidence to classify carbon black as a carcinogen in mice. In a more recent assessment, an International Agency for Research on Cancer (IARC) expert working group concluded that there was inadequate data to permit an evaluation of its carcinogenicity in experimental animals. Furthermore, they found that “the available epidemiological data provide inadequate evidence to evaluate the carcinogenicity to humans of carbon blacks”.\(^5\) There was, however, sufficient evidence that solvent extracts of carbon black are carcinogenic to experimental animals.

Carbon blacks are known to adsorb polyaromatic hydrocarbons such as benzo[a]pyrene,\(^1\) but their elution is difficult particularly by body fluids.\(^8\) The bioavailability of these compounds seems to depend on the relation between the amount of adsorbed material and the available adsorptive surface.\(^3\) It has been suggested, however, that high boiling oils used with carbon black in inks “would act as eluents for cancer-producing chemicals adsorbed on the carbon”.\(^7\)

For mineral oils, another IARC expert working group\(^6\) found sufficient evidence to classify certain grades of oil as carcinogenic in experimental animals. They, however, regarded as inadequate the evidence with respect to the carcinogenic activity of formulated products based on mineral oils such as printing inks.

Analyses of newspaper inks used in London and Manchester in 1978 found measurable concentrations of benzo[a]pyrene in the range 2–59 μg/g.\(^4\) Mean atmospheric concentrations of benzo[a]pyrene in newspaper pressrooms in the same study were 26-9 μg (range 4-1–75-6) μg/1000 m\(^3\).

Another study of British newspaper pressrooms found the concentration of benzo[a]pyrene, in atmospheric particles < 6 × 10\(^-4\) m, to be 5-2–18-0 μg/m\(^3\).\(^6\) The same investigation found a mean concentration of benzo[a]pyrene of 8-32 μg/g in a random sample of 92 letterpress newspaper inks manufactured in the United Kingdom in the early 1980s.

To place these concentrations of benzo[a]pyrene in context, around 26 μg/1000 m\(^3\) were present in newspaper pressrooms in 1975, compared with street concentrations in London at the time of around 1–2 μg/1000 m\(^3\).\(^4\) These concentrations are three or four orders of magnitude below those measured in gasworks retort houses and in areas where roof tarring was being carried out.\(^17\) It should be noted that in these studies of the inks, benzo[a]pyrene was used as a convenient marker for the presence of carcinogenic polyaromatic hydrocarbons (PAHS), although it is certain that there were other polyaromatic hydrocarbons in newspaper inks,\(^6\) which may have also been biologically relevant.

In summary, ink mists in newspaper pressrooms contain known carcinogens, such as benzo[a]pyrene. An appreciable proportion of their mass is adsorbed onto particles of respirable size. There remains some doubt as to the bioavailability of such polyaromatic hydrocarbons, the evidence from experimental animals being inadequate to assess whether carbon black is carcinogenic in such systems. No objective data exist for concentrations of ink mists in press rooms before the 1960s, although since this time concentrations seem to have been reduced.

**OTHER EPIDEMIOLOGICAL STUDIES**

A number of studies have been published that report on the risk of lung cancer among print workers. Only a few\(^2-18\) provide information on risk of lung cancer among newspaper pressmen, most\(^29-34\) failing to differentiate between pressmen and other occupational groups in the industry.

Deaths among newspaper pressmen in Manchester (1952–66) were the subject of a proportional mortality study.\(^9\) Twice the expected number of deaths from lung cancer were observed (proportional mortality ratio (PMR) = 203, 95% CI 143–274). The study, however, failed to find any suggestion of a similar excess among a parallel group of men in London, consistent with another analysis of the same population.\(^35\) There is considerable overlap between the Manchester deaths in that study and those in our Manchester cohort study. Its results, therefore, cannot be considered as providing independent support for the findings of our cohort study.

Another proportional mortality study\(^36\) analysed 2604 deaths identified from the death benefit records of a national printing trade union in the United States for the
Lung cancer among newspaper exposed to ink mist: a study of trade union members in Manchester, England

period 1966–68. Newspaper pressmen had a slightly higher proportion of deaths from lung cancer than expected from national death rates (PMR = 113, 95% CI 81–153). In a cohort study from the United States, 1361 newspaper pressmen who had belonged to the Los Angeles Pressmen’s Union between 1949 and 1965 were followed up to the end of 1978, vital status being ascertained for 91% of the cohort. Mortalities were compared with those for the United States white male population as a whole by the calculation of age and calendar period adjusted SMRs. The study reported a lung cancer SMR of 192 (95% CI 92–219).

The largest, best designed, and executed of the studies was a cohort of 1769 newspaper pressmen from New York. Men who at the beginning of 1950 were active, retired, or beneficiary members of the New York branch of a printing trades union were followed up to the end of 1976. Vital status was ascertained for 98.6% of the cohort. Two separate comparisons were made of mortality in the cohort. One was with the whole United States white male population and the other with the white male population of New York City. Both sets of comparisons were expressed as age and calendar period adjusted SMRs.

Compared with rates for the United States, our study found an SMR of 152 (95% CI 121–192). When compared with New York rates, the effect was reduced (SMR = 131, 95% CI 104–166). Significantly raised mortality was also found for non-infectious respiratory disease (including bronchitis), with SMRs of 148 (95% CI 112–195) based on United States rates and 243 (95% CI 185–321) based on New York rates. Hypothetical estimates of the effect of pressmen smoking more than the average suggested that such differences could not explain all of the increased mortality from lung cancer or of non-infectious respiratory disease.

The increased mortality of lung cancer among NATSOPA machine assistants seen in the Manchester cohort study is therefore supported by the parallel findings of other studies. Combining the data from the two cohort studies of newspaper pressmen with those from the Manchester cohort study, and with expected deaths derived from local rates where provided, gives a pooled SMR of 129 (95% CI 110–148), based on 188 deaths.

Several studies found deficits of bronchitis or of non-malignant respiratory disease as a whole. Like the machine assistants in the Manchester cohort study, the New York cohort of newspaper printers had raised SMRs for bronchitis and emphysema; moreover, these increased when New York, as opposed to national United States rates, were used to calculate the expected values.

In conclusion, the epidemiological reports support the notion that men involved in newspaper printing have an increased risk of lung cancer. The magnitude of this excess is moderate. The pooled SMR suggests around a 30% increase in risk above that of the general population. This is within the range that might be explained by confounding by tobacco smoking. The increased rates for bronchitis among pressroom men in the Manchester cohort study and in the similar investigation of New York pressmen could be regarded as providing further support for smoking being a confounder.

The case-control data suggest that there may be a dose-response effect, although the finding is not statistically significant. The existence of such an effect would be difficult to explain by confounding with smoking. Further, indirect support for a real effect of work in newspaper press rooms on risk of lung cancer comes from the finding in the Manchester cohort study that the parallel group of NGA rotary machine managers have a raised SMR for lung cancer that is atypical of the union as a whole but the lowest SMR of any occupational group for bronchitis.

An occupational risk of lung cancer in newspaper printing is biologically plausible. Men working in pressrooms operating rotary letterpress machines were exposed to ink mists that are known to contain carcinogens. From a biological point of view, the main weakness of the evidence concerns the uncertainty over whether the carcinogens that are taken into the respiratory tract would be able to be biologically active, as they would tend to be strongly adsorbed on the carbon black pigment.

The case is therefore not established, but is weakly suggestive of a true occupational effect. Any association between exposure to rotary letterpress ink mist and lung cancer may constitute a diminishing problem in Britain, due to the changes in newspaper printing technology over the past decade. Those rotary letterpress machines that still exist (as in Manchester) are being replaced by the offset litho machines that are now used almost exclusively in the printing of national papers in London. These presses use different types of ink, which, although based on mineral oil, do not contain carbon black, and are much less prone to produce ink mists in pressrooms. The findings of this study are of current relevance, however, in countries where rotary letterpress technology is still widely used.

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Leon, Thomas, Hutchings


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