



Department for Work and Pensions

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Security Administration Act 1992

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**Report by the Industrial Injuries Advisory Council in
accordance with Section 171 of the Social Security
Administration Act 1992 considering prescription for lung
cancer in coke oven workers**

*Presented to Parliament by the Secretary of State for Work and Pensions
By Command of Her Majesty
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INDUSTRIAL INJURIES ADVISORY COUNCIL

Secretary of State for Work and Pensions

Dear Secretary of State,

REVIEW OF LUNG CANCER IN COKE OVEN WORKERS

We present our review of lung cancer in coke oven workers. This matter was last considered by the Council in 1986 in the Command paper 'Occupational Lung Cancer', when the evidence base was limited to findings from a large US mortality study and two smaller UK studies. The US study indicated an increased risk of lung cancer in coke oven battery workers, though not other coke plant workers, which was greatest in those incurring the higher exposures to emissions associated with top oven work. However, estimates of risk were smaller in the UK studies and insufficient at the time to reach the threshold normally applied in recommending prescription.

Since 1986 findings from a number of additional studies have been published internationally, involving long-term follow-up in workers principally exposed before the 1980s. Also, an extended follow-up in one of the UK study populations has furnished further information on the long-term risk in British workers. Collectively, these updated findings suggest a more than doubled risk of lung cancer among coke oven workers with greater exposures (especially workers engaged in top oven activities), but not workers engaged in general non-oven coke plant duties. A persuasive case now exists for recommending prescription.

Exposure levels to carcinogenic agents are likely to have reduced substantially since the 1970s, following better engineering and personal safety controls in the industry. The Council considered, therefore, whether a cut-off date could be defined after which prescription would no longer be warranted. Current evidence is insufficient to define such a cut-off date.

The Council recommends that lung cancer associated with (i) at least five years in total of work at the top of a coke oven or (ii) at least 15 years in total of coke oven work, should be added to the list of prescribed diseases. For workers who move between these coke oven jobs, and whose employment in top oven work amounts to less than five years in total, we recommend that each year of top oven work be counted as contributing three years towards the greater target of 15 years, as set out in further detail in our report.

Yours sincerely,

Professor K Palmer

Chairman

13 September 2011

Summary

1. The production of coke takes place in coke making plants, in large batteries of ovens in which coal is heated to high temperatures for several hours. Coal is charged into the oven through a series of holes in the oven top, and the product coke is pushed sideways out of the oven through doors at each end. During this process coke oven workers may be exposed to various emissions which are complex mixtures of chemicals and gases and which may include known or suspected carcinogens.

2. In 1986 IAC published its Command Paper 'Occupational Lung Cancer' which included consideration of increased risks to coke oven workers. At that time there was insufficient evidence to warrant prescription, but IAC agreed to keep the matter under review. IAC has recently reviewed the evidence relating to lung cancer in coke oven workers, alongside that of lung cancer in certain other occupations which have been (e.g. 'Lung cancer in foundry workers' and 'Silica and lung cancer in the absence of silicosis'), or will be, the subject of other reports.

3. When IAC originally considered this subject the evidence base was limited to the results of a large US mortality study, which covered 30 years of follow-up, and two smaller UK studies where follow-up was limited to less than 15 years.

4. The US study provided evidence of a more than doubling of risk of lung cancer in coke oven workers, though not other general coke plant workers. This risk was further increased in those with experience of the higher exposures associated with top oven work. However, the results of the UK studies did not support this conclusion, finding only a moderately increased risk in coke oven workers. It was recognised that follow-up time was rather limited relative to the late onset of the disease in question.

5. Since that time a number of other studies, from different countries, have been published, and one of the UK studies has reported on a further nine years of follow-up.

6. The results of the new studies confirm the view that the increased risk is confined to coke oven workers rather than coke plant workers in general. In addition, the results of the extended follow-up of the UK study support the US findings and suggest a more than doubling of risk in some circumstances of exposure.

7. The Council recommends that lung cancer associated with (i) at least 15 years of coke oven work, or (ii) at least five years of top oven work (as specified in the recommendations of the report), should be added to the list of prescribed diseases.

8. Some claimants may incur a mixture of such exposures, moving between top oven and other oven duties during the course of a working lifetime. Where such an individual is employed in top oven work for fewer than five years in total (i.e. fails to meet the first criterion), in recognition of the higher risks conferred by time spent in top oven work, we recommend that each year of top oven work be counted as contributing three years towards the 15-year threshold that remains open to claimants (the second criterion).

This report contains some technical terms, the meanings of which are explained in a concluding glossary.

Introduction

9. In 1986 the Industrial Injuries Advisory Council (IIAC) published its Command paper 'Occupational Lung Cancer' which included consideration of haematite (iron ore) miners, coke oven/gas retort workers, foundry workers (heat treatment loaders, furnacemen, fitters, foundry labourers, furnace repairers, iron and steel foundry workers), rubber workers, manufacturers of man-made mineral fibres, workers exposed to formaldehyde and furskin workers. At that time there was insufficient evidence to warrant prescription for any of these occupations, but IIAC agreed to keep the matter under review. In September 2009 the Council revisited the evidence relating to these occupational categories and now finds that evidence relating to lung cancer in coke oven workers is sufficiently strong to consider prescription for this exposure. The other occupational categories have been ('Lung cancer in foundry workers', 'Silica and lung cancer in the absence of silicosis'), or will be, considered in separate reports.

The Industrial Injuries Disablement Benefit Scheme

10. IIAC is an independent statutory body set up in 1946 to advise the Secretary of State for Work and Pensions in Great Britain and the Department for Social Development in Northern Ireland on matters relating to the Industrial Injuries Scheme. The major part of the Council's time is spent considering whether the list of prescribed diseases for which benefit may be paid should be enlarged or amended.

11. The Industrial Injuries Disablement Benefit (IIDB) Scheme provides a benefit that can be paid to an employed earner because of an industrial accident or Prescribed Disease.

The legal requirements for prescription

12. The Social Security Contributions and Benefits Act 1992 states that the Secretary of State may prescribe a disease where he is satisfied that the disease:

- a) ought to be treated, having regard to its causes and incidence and any other relevant considerations, as a risk of the occupation and not as a risk common to all persons; and
- b) is such that, in the absence of special circumstances, the attribution of particular cases to the nature of the employment can be established or presumed with reasonable certainty.

13. In other words, a disease may only be prescribed if there is a recognised risk to workers in an occupation, and the link between disease and occupation can be established or reasonably presumed in individual cases.

14. In seeking to address the question of prescription for any particular condition, the Council first looks for a workable definition of the disease. It then searches for a practical way to demonstrate in the individual case that the disease can be attributed to occupational exposure with reasonable confidence. For this purpose, reasonable confidence is interpreted as being based on the balance of probabilities according to available scientific evidence.

15. Within the legal requirements of prescription it may be possible to ascribe a disease to a particular occupational exposure in two ways – from specific clinical features of the disease or from epidemiological evidence that the risk of disease is at least doubled by the relevant occupational exposure.

Clinical features

16. For some diseases attribution to occupation may be possible from specific clinical features of the individual case. For example, the proof that an individual's dermatitis is caused by his/her occupation may lie in its improvement when s/he is on holiday, and regression when they return to work, and in the demonstration that they are allergic to a specific substance with which they come into contact only at work. It can be that the disease *only* occurs as a result of an occupational hazard (e.g. coal workers' pneumoconiosis).

Doubling of risk

17. Other diseases are not uniquely occupational, and when caused by occupation, are indistinguishable from the same disease occurring in someone who has not been exposed to a hazard at work. In these circumstances, attribution to occupation on the balance of probabilities depends on epidemiological evidence that work in the prescribed job, or with the prescribed occupational exposure, increases the risk of developing the disease by a factor of two or more.

18. The requirement for, at least, a doubling of risk follows from the fact that if a hazardous exposure doubles risk, for every 50 cases that would normally occur in an unexposed population, an additional 50 would be expected if the population were exposed to the hazard. Thus, out of every 100 cases that occurred in an exposed population, 50 would do so only as a consequence of their exposure while the other 50 would have been expected to develop the disease, even in the absence of the exposure. Therefore, for any individual case occurring in the exposed population, there would be a 50% chance that the disease resulted from exposure to the hazard, and a 50% chance that it would have occurred even without the exposure. Below the threshold of a doubling of risk only a minority of cases in an exposed population would be caused by the hazard and individual cases therefore could not be attributed to exposure on the balance of probabilities; above it, they may be.

19. The epidemiological evidence required should ideally be drawn from several independent studies, and be sufficiently robust that further research at a later date would be unlikely to overturn it.

20. Lung cancer is not exclusively occupational and does not have unique clinical features when it occurs in an occupational context. The case for prescription, therefore, rests on reliable evidence of a doubling or more of risk in coke oven workers after allowance for other non-occupational risk factors.

Lung cancer

21. Lung cancer is the second most common cancer in the United Kingdom with around 39,000 people diagnosed per year. The predominant risk factor for lung cancer is cigarette smoking (associated with 9 out of 10 cases). Other risk factors include exposure to certain substances, such as asbestos or radon, or familial predisposition. Over two-thirds of people diagnosed with lung cancer are over 65 years old.

22. Lung cancers can be classified into two types: small cell lung cancers and non-small cell lung cancers, based on the appearance of the tumour cells under a microscope. The latter is the most common form, accounting for 80% of all lung cancers.

23. Symptoms of lung cancer include cough, shortness of breath, coughing up blood stained sputum, chest pain and loss of appetite or weight. Lung cancer can be diagnosed by chest radiograph, computer tomography (CT) or magnetic resonance imaging (MRI) scans, or bronchoscopy with lung biopsy. Treatment may include chemotherapy, radiotherapy or surgery. The prognosis for lung cancer is highly dependent on the progression and type of the tumour.

Coke oven work

24. Coke is produced in coke making plants, by blending and heating coal at high temperatures in the absence of oxygen. These plants transform coal into a dense, crush resistant fuel, known as coke, for use in blast furnaces and other industries and allow the collection of usable chemical and gas by-products, such as ammonia, benzene, toluene, tar, oil and methane. A coke making plant consists of the coal handling area, the coke oven batteries (where coke is produced), the coke handling area and the by-products plant.

25. Coke batteries are organised into large numbers of ovens, typically 25 to 66 ovens on each battery grouped in one, two (most often) or three operating units, comprising of 42-88 chambers which are made up of heating chambers, coking chambers and regenerative chambers (for storing and re-using heat). The ovens are arranged side-by-side and charged and discharged in a cyclical manner in a continual process. Coal is charged through holes in the top of the oven, and then coke is discharged through doors located at the sides of the oven and sent to the coke handling plant, while by-products are routed through pipes to the by-product plant.

26. In the UK, coke is used mostly in blast furnaces at integrated iron and steel works. Currently there are 6 coke making plants in the UK, 5 of which are situated at integrated steel works. Coke may also be used in the synthesis of calcium carbide.

Health Risks

27. Coke oven emissions are complex mixtures of chemicals and gases which may include known or suspected carcinogens and toxins, such as polycyclic aromatic hydrocarbons (PAHs), formaldehyde, phenol, cadmium, arsenic and mercury. Coke oven emissions have been linked to various cancers, including lung cancer, the focus of the present report.

Consideration of the evidence

28. A number of studies investigating the link between exposure to coke oven emissions and lung cancer have been carried out since the early 1960s. The majority of these have been cohort studies in which the rate of death due to lung cancer in coke plant workers is compared to that either in the general population, or in another worker population. Cohort studies typically overcome the practical problem of long latency (the many years an investigator has to wait between exposure and cancer onset) by studying populations in retrospect using records of employment, linked with databases of cancer registry or more usually death certification. Such studies usually focus on specific workforces and contain information about employment duration, sometimes supplemented by supporting exposure measurements. However, they rarely contain information on important confounders such as the smoking habits of the workforce, an important factor in studying causes of lung cancer.

29. Much of the evidence in this field derives from a single long-term mortality study carried out by a research group at Pittsburgh University in the USA and published in a series of papers between 1969 and 1983. The results of this study provide the most compelling evidence for an association between employment as a coke worker and lung cancer.

30. The original cohort consisted of 58,828 steelworkers employed in 1953 at seven plants in Allegheny County, Pennsylvania. The seven plants included two coke plants employing 2,543 workers (subsequently termed the 'Allegheny cohort'). Steel workers who had never worked in the coke plants were used as a comparison group for calculating expected deaths and mortality ratios. Findings over the first follow-up period, from 1953-1961, indicated an excess risk of lung cancer in coke plant workers overall (Relative Risk (RR) 1.70, $p < 0.05$) (Rockette and Redmond, 1985). However, separate analysis for coke oven workers showed that in this group the risk was more than doubled (RR 2.48, $p < 0.01$), while that for non-oven workers was 0.47.

31. Subsequent follow-up of this cohort to 1966, and later to 1970 confirmed a significantly increased risk which was confined specifically to coke oven workers (Redmond *et al.*, 1976). In 1966, for cancer of the lungs, bronchus and trachea, the RR for coke oven workers ($n=1,316$) was 3.31 ($p < 0.01$) and for non-oven workers ($n=1,227$) it was 1.01. The difference in risk associated with the two groups was accentuated when workers only employed for more than five years were considered (oven workers RR 3.67, $p < 0.01$, non-oven workers RR 0.51).

32. In the 1970 report, coke oven workers were further sub-divided into three exposure groups reflecting increasing duration of exposure. The results indicated increasing risk with employment duration (5 or more years, RR 3.02; 10 or more years, RR 3.42; 15 or more years RR 4.14). In all cases $p < 0.01$.

33. In the 1970 follow-up further analysis on the basis of employment type indicated higher risks in topside oven workers than side oven workers. For those employed full-time as topside oven workers RRs for the three employment duration groups were 9.19, 11.79 and 15.72 respectively (in each case $p < 0.01$). For those employed part-time as topside oven workers the respective figures were 2.29, 3.07 and 4.72 (in each case $p < 0.01$). For side oven workers the figures were 1.79, ($p < 0.005$); 1.99, ($p < 0.05$) and 2.00, (not statistically significant) (Rockette and Redmond, 1985).

34. In addition to this analysis of the Allegheny cohort a further follow-up to 1966 was carried out which included the Allegheny cohort plus ten additional plants, (the 'non-Allegheny cohort'), situated in various locations around the US and Canada. This additional cohort included all coke oven workers ($n=4,661$), who were compared with other workers matched on age, employment date and race. All participants had been originally employed between 1951 and

1955 and follow-up was from 1951. A particular focus of this analysis was the investigation of suggestions of a higher risk among non-white workers. Results indicated similar risks in white and non-white workers when exposure levels were taken into account. Overall the RR for workers employed in all plants was 2.85, ($p < 0.01$). Subsequent follow-up of the two cohorts to 1975 indicated RRs of 2.63, $p < 0.01$ (Allegheny cohort) and 2.49, $p < 0.01$ (non-Allegheny cohort) (Redmond *et al.*, 1983).

35. A final follow-up was carried out in 1982 (Costantino *et al.*, 1991). This included the non-Allegheny cohort plus a subset of the original Allegheny cohort which included all coke oven workers from the two coke plants in the original cohort ($n=2,025$), and a matched sample of non coke oven workers ($n=4,032$). (Minor discrepancies in worker numbers compared with earlier cohorts were due to some reclassification of job titles following more detailed assessment of work histories.) Overall the RR for cancer of the lungs, bronchus and trachea in coke oven workers was 1.95 (95% confidence interval (95% CI) 1.59-2.33).

36. Further analysis indicated increasing risk by duration of employment (Costantino *et al.*, 1991). After ten years of employment a statistically significant risk was observed (RR 1.82, 95% CI 1.26-2.99), which was more than doubled after 15 years of employment (15-19 years RR 2.91, 95% CI 2.27-4.52; ≥ 20 years, RR 2.71, 95% CI 1.76-2.85). For the subset of topside oven workers risks were higher. A statistically significant risk was observed after 1-5 years of employment (RR 1.67, 95% CI 1.41-2.51) and following five years of employment this risk was more than doubled (5-9 years RR 2.58, 95% CI 1.75-4.23), rising to 4.34 (95% CI 2.89-6.97) after 20 or more years of employment.

37. Although data on smoking were unavailable in this study, the authors argued that there were no particular reasons to suppose that coke oven workers differed markedly from the non coke oven workers in terms of smoking habits. In addition, the magnitude of some of the increased risks reported in this study would be unlikely to be accounted for by smoking alone.

38. In addition to the Pittsburgh study, two mortality studies have been carried out in the UK, those of Davies, (1977) and Hurley *et al.* (1983, 1991).

39. Davies (1977) studied mortality in 610 coke oven workers employed in May 1954 at two steelworks in South Wales. Follow-up was from 1954 to 1965. Using the general population for comparison, no excess of lung cancer was observed in the coke oven workers (8 observed cases, 9.76 expected). However, this was a relatively small study and the follow-up period was short given the long latency (interval to disease onset) associated with lung cancer.

40. Hurley *et al.* (1983) studied a total of 6,767 coke plant workers employed at the British Steel Corporation (BSC) and National Smokeless Fuels (NSF). Follow-up periods were again relatively short, for 12 years and 13 years respectively. Information on smoking habits obtained from some workers suggested that smoking habits were similar to those in the general population. The combined Standardised Mortality Ratio (SMR) for lung cancer in the 27 plants of the two companies was 1.171¹ when compared to regional rates and 1.05 when compared to rates for semi-skilled men in the general population. There was no convincing evidence in either cohort that risks related to years of employment in oven work.

41. However, a subsequent follow-up of these workers (Hurley *et al.* 1991), which extended the follow-up period to 20 years and introduced a more detailed occupational classification system, found evidence of a more than doubled risk in certain circumstances. For coke plant workers overall, compared to regional rates, the increased risk was moderate (SMR for NSF workers was 1.25 and for BSC workers 1.27). Similarly, compared to rates for semi-skilled workers, SMRs were unremarkable (1.04 and 1.10 respectively). However, risks were higher among oven workers, with some variation by employer and statistical model of analysis. For NSF workers, RRs tended to increase with duration of work on general oven jobs (which included foremen and general maintenance work, but not the specialised jobs on ovens tops or sides), and in one statistical (Cox) model a more than doubling of risk (RR 2.29, 95% CI 1.21-4.33) was estimated per ten years of work on general ovens jobs. A possible relation between lung cancer mortality and length of employment in top oven work at NSF was also found, although this did not reach statistical significance. However, for BSC workers the relationship was more clear-cut, with risks more than doubled among those in top oven work for more than five years (RR 2.10, 95% CI 1.22-3.61), relative to men with no recorded experience of this type of work². An analysis which allowed for smoking habits estimated a RR of 2.40 (95% CI 0.76-7.55) per 10 years of top oven work. These results show some consistency with those of the Pittsburgh study in identifying an increased risk in oven workers and in top oven workers in particular, although the magnitude of the increased risk was smaller in the British data.

42. Three other studies have investigated lung cancer rates in retired workers. Bertrand *et al.*, (1987) studied 534 French workers who had retired from two coke plants after January 1st 1963 and followed them to 1982. Mortality from

¹By convention, SMRs, which are forms of relative risk, are multiplied by 100. Thus, for example, in the original publication, this value was 117. In this report, to facilitate comparison with other estimates of relative risk and to simplify, SMRs are presented without such multiplication. The concluding glossary gives further details.

²This analysis was based on the so-called Poisson regression method. An analysis based on the Cox method (which treats risk as constant per unit time, rather than potentially varying), estimated a somewhat lower RR, of 1.81 ($p < 0.05$) per 10 years of exposure without allowance for smoking.

lung cancer was compared with national rates. Overall the SMR for coke plant workers was 2.51 ($p < 0.01$), although it was much higher in plant A (SMR 3.05) than in plant B (SMR 1.75). No increase was observed in those employed in coke oven work compared to non oven work or with duration of coke oven work (<5 years SMR 2.35; ≥ 5 years SMR 2.78). Although smoking was not taken into account in this study the authors conducted a separate analysis of 77 lung cancer cases whose smoking habits were known and matched to these controls in terms of smoking. They observed that 47% of cases were occupationally exposed to dust, gas and fumes compared to 35% of the controls, suggesting a role for occupational exposure over and above that of smoking, although they noted that the difference was not statistically significant.

43. Bye *et al.* (1998) carried out an incidence and mortality study at a coke plant in Norway involving 888 former workers employed for at least one year. Rates were compared with national population rates. Follow-up was from 1962-1993. The Standardised Incidence Ratio (SIR) for lung cancer was 0.82 (95% CI 0.33-1.70). However, a significant increase in lung cancer incidence was observed for those with the highest cumulative exposure to PAHs (≥ 150 mg/m³-years). In this group the SIR was 3.60, although there were no cases in other exposure categories (p value for trend 0.08).

44. Sakabe *et al.* (1975) studied 2,178 retired coke oven workers from 11 firms, which included iron and steel works and city gas companies. The authors noted a significant excess of lung cancer deaths in workers employed in the iron and steel works (Standardised Mortality Ratio (SMR) 2.37), although not in workers from the gas companies.

45. Two further studies indicate a moderately increased risk of lung cancer in coke workers. Swaen *et al.* (1991) studied mortality rates in 5,659 workers employed for at least six months at three coke plants in the Netherlands. They were compared with 5,740 nitrogen fixation plant workers and follow-up was from 1945-1969. For all coke oven workers the SMR was 1.29 (95% CI 0.99-1.65). In top oven workers the authors report a significantly increased risk of mortality from respiratory disease, although this was not exclusively lung cancer (SMR 1.75, 95% CI 1.07-2.70). Side oven workers showed a significantly increased risk of lung cancer (SMR 1.41, 95% CI 1.03-1.90).

46. In Italy, Franco *et al.* (1993) studied 538 workers at a coke production plant employed between 1st January 1960 and 31st December 1985. Follow-up was from 1960-1990. The SMR for lung cancer was 1.90 (95% CI 1.14-2.96) compared with national rates and 1.70 (95% CI 1.02-2.65) compared with regional rates.

47. In addition to these mortality and morbidity studies two case-control studies have been carried out in Canada (Finkelstein, 1994) and in China (Xu *et al.* 1996). The occupational history in case-control studies is obtained retrospectively (usually by asking the subject) and may be subject to reporting bias. For example, those suffering from disease may be more likely to recall certain occupations or exposures than those not suffering from disease. However, the opportunity exists to ask about smoking habits and other possible relevant exposures and thus allow for these factors in the analysis.

48. Finkelstein (1994) carried out a population-based case-control study in two cities in Ontario, Canada where two steel plants were situated. Males who died from lung cancer (n= 967) between 1979 and 1988 were compared to 2,827 age and sex matched subjects who died from other causes. In this case researchers obtained each subject's last occupation from death certificates and, where these were recorded as steelworkers, sought more information on occupational history from previous employers. No increased risk was identified for steelworkers overall when compared either with general population rates or with rates for blue collar workers. The authors note that because of small numbers the statistical power to investigate lung cancer risk by specific work area, such as coke plants, was low. At two plants there was no increased risk among coke workers. However, in one plant, they reported an RR of 1.78 (95% CI 0.3-9.3) for coke oven workers with more than 5 years employment. At this plant five of the seven men who had ever worked at the coke ovens died from lung cancer.

49. Xu *et al.* (1996) studied 610 cases (552 men, 58 women) and 959 controls in a nested case-control study derived from a proportional mortality study of workers at a large iron and steel complex. Following adjustment for smoking and other pulmonary disease the Odds Ratio (OR) for ever having worked in coke oven work was 3.6 (95% CI 1.7-7.5). There was no increased risk with years of employment, (<15 years employment OR 3.9, 95%CI 1.3-12.4; ≥15 years employment OR 3.4, 95%CI 1.4-8.5).

Conclusions

50. The studies considered here are consistent in indicating a statistically significant increased risk of lung cancer associated with work involving coke ovens. The majority found a more than doubling of risk either in certain groups of workers or in association with certain durations of exposure.

51. The various results deriving from the Pittsburgh investigation provide the most compelling evidence of an association between coke oven working and lung cancer. In this study, a more than two-fold increase in risk appeared to be confined to those employed in oven working and increased with years of employment. Moreover, particularly high risks were identified in those

employed in top oven, as opposed to side oven, work. The more conservative estimates of the Pittsburgh study, reported at final follow-up, continue to point to an increased risk which is more than doubled after five years employment for top oven workers, and fifteen years for other oven workers.

52. Other studies provide support for the view that increased risks are largely confined to oven workers and that these risks are further increased in those with experience of top oven work. Hurley *et al.* in their later follow-up found that, in one group of workers, more than ten years employment in general oven work and more than five years in top oven work was associated with more than a doubling of risk. Bye *et al.* did not distinguish occupational groups but identified a more than three-fold risk in those with the highest exposure to PAHs (which would include oven workers and particularly top oven workers). In a nested case-control study Xu *et al.* reported an OR of 3.6 for ever having been employed in coke oven work and the population-based case-control study of Finkelstein, although based on small numbers of coke oven workers, provides some supporting evidence for an increased risk. Set against this, Bertrand *et al.* found no difference between oven and non-oven workers, although reporting a more than two-fold risk for coke workers overall. Sakabe *et al.*, who reported a two-fold risk and Franco *et al.*, who reported a risk slightly less than doubled, did not distinguish between oven and non-oven workers.

53. Smoking is a potent risk factor for lung cancer and an important potential confounder in occupational studies. Few studies had access to data on smoking history and most relied on an assumption that exposed subjects were unlikely to differ markedly from controls in terms of smoking habits. It was noted in a number of studies, however, that increased risks in coke oven workers were much above those which could be attributed to smoking alone. Moreover, in the case-control study described in paragraph 49, which included adjustment for smoking, a more than three-fold risk was identified.

54. When the Council originally considered this subject the evidence base was limited to the early results of one US based study (the Pittsburgh study) and two UK based studies, which excluded the later follow-up of the Hurley *et al.* study reported in 1991. Neither of the UK studies suggested that risks were as much as doubled.

55. The Council considered that in these circumstances prescription could not be justified. However, the availability of a further follow-up of the study by Hurley *et al.* and the publication of several other studies has altered this picture considerably.

56. Current evidence appears to be consistent in indicating a more than doubling of risk of lung cancer in coke oven workers. Further, the balance of evidence supports the view that for top oven workers, the risk is more

than doubled after five years and for other oven workers after 15 years of employment. The Council recommends prescription under each of these circumstances.

57. The possibility exists that some workers may have moved between top oven and other oven duties over the course of their career. In doing so they may fail to meet the threshold of five years of employment in top oven work. However, by virtue of the more highly exposed portion of their employment, they may nonetheless bear added risk relative to workers who have worked solely in general oven duties. In light of the epidemiological evidence indicating that risks of lung cancer in top oven workers tend to double after an interval of about five rather than 15 years, the Council considers that it would be equitable to count each year of top oven work as contributing three years towards the 15-year target in the assessment of claimants with such combined exposures.

58. During the course of its enquiries, the Council received evidence from representatives of the industry indicating substantial improvements in working conditions since the early 1970s, and a considerable reduction in workers' exposures to PAHs. Likewise, a research report from Norway has indicated a reduction of some 60% in exposures in 1977–1987 as compared with 1976 (Romanstad *et al.*, 1998). Better exposure controls are likely to have lessened risks of lung cancer. Consideration was given, therefore, to whether a cut-off date for employment could be defined after which prescription might no longer apply. However, in the absence of published evidence to confirm that reduced exposures have translated into reduced health risks, or any exact understanding of exposure-response relationships, the Council has decided that there is no certain basis for defining such a cut-off date. Should further evidence on this emerge in future, the Council will revisit the question.

59. The Council has also received evidence to suggest that exposure levels to potential carcinogens have been higher historically in the US than in British industry. Nevertheless, the Council considers the evidence in British industry sufficiently compelling to accept the case for prescription.

Recommendations

60. The Council recommends that lung cancer associated with (i) at least five years of work at the top of coke ovens in aggregate, or (ii) at least 15 years of coke oven work in aggregate should be included in the list of prescribed diseases.

61. Should the first of these thresholds not be met, then the total duration of employment in top oven work should count towards the second threshold, and be aggregated such that one year of top oven work is regarded as equivalent to three years of general oven work. Thus, for example, a worker employed in top oven work for four years in aggregate, and so failing to meet the first criterion for prescription, could satisfy the second if it were to be established that they had also been employed for at least three years in total in other oven duties.

62. The Council further recommends that to be reckonable against these qualifying time limits, workers should be wholly or mainly employed in the relevant job category or categories.

63. The term 'top oven work' includes a number of job titles and evidence has been sought on the extent to which the work activities of top oven and non-top oven workers overlap, and can be distinguished under the practical circumstances of the IIDB scheme. As a result of these enquiries the Council recommends that the following job titles should be included as counting specifically to top oven work: lidsman, car man (chargerman), valveman or tarman, top oven maintenance worker. This is not an exhaustive list but includes job titles which were employed in the British study carried out by Hurley *et al.* and are judged to be readily understood within the current industry.

64. The recommendations for prescription are described in the table below.

Disease	Occupation
Lung cancer	Employment wholly or mainly: <ul style="list-style-type: none"> <li data-bbox="547 976 1326 1048">(a) as a coke oven worker for a period in aggregate of at least 15 years; <li data-bbox="595 1066 627 1093">or <li data-bbox="547 1111 1326 1227">(b) as a coke oven worker employed specifically in top oven work for a period in aggregate of at least 5 years; <li data-bbox="595 1245 627 1272">or <li data-bbox="547 1290 1326 1438">(c) in a combination of top oven and other oven duties, such that each year in top oven work be treated as equivalent to 3 years working in other oven duties, the aggregated sum amounting to 15 years in total.

65. Where these conditions of prescription are satisfied, a claimant's lung cancer should be presumed to arise from their occupation, regardless of their smoking history.

Prevention

66. The Control of Substances Hazardous to Health Regulations 2002 (COSHH), (as amended), apply across the workplace and thus include where work is carried out in or around the vicinity of a coke oven. The Regulations require that work is not carried out which is liable to expose any employees to any substance hazardous to health unless a suitable and sufficient assessment has been made of the risks created by the work and appropriate measures are

taken to prevent exposure as far as is reasonably practicable. Where it is not reasonably practicable to prevent exposure by elimination or substitution with a safer substance or total enclosure, exposure must be adequately controlled by the use of appropriate work processes, systems and engineering controls and measures to control exposures at source. Suitable respiratory protective equipment may be used in addition where adequate control cannot be otherwise achieved. Those working in areas of the workplace where exposure is likely to happen, such as in or around the coke oven vicinity, should be informed of the hazards/risks and be provided with the appropriate training. Additionally, COSHH may require employers to arrange appropriate health surveillance.

Diversity and equality

67. The Industrial Injuries Advisory Council is aware of issues of equality and diversity and seeks to promote as part of its values. The Council has resolved to seek to avoid unjustified discrimination on equality grounds, including age, disability, gender reassignment, marriage and civil partnership, pregnancy and maternity, race, religion or belief, gender and sexual orientation. During the course of the review of lung cancer in coke oven workers no diversity and equality issues were apparent. It should, be noted, however, that the employment of women in this occupation is rare and that conclusions have been drawn from the results of studies involving only or mainly male workers.

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Experts consulted³

Dr John Unwin, Mr John McAlinden and Mr Chris Keen, Health and Safety Executive

Dr Sally Williams, MB BCh FRCP AFOM, Regional Medical Officer, Tata Steel

Mr David Wilcox, BSc (Chem Eng), C Eng, CSc, FIChemE , Works Manager, TATA Steel

Mr Fintan Hurley, Institute of Occupational Medicine, Edinburgh

³The Council wishes to thank the experts consulted and to note that inquiries were restricted to matters of fact – on the nature of working conditions and/or risks in coke oven workers – rather than the opinions of individuals on the merits of prescription.

Glossary of terms used in this report

Types of study

Case-control study: A study which compares people who have a given disease (cases) with people who do not (controls) in terms of exposure to one or more risk factors of interest. Have cases been exposed more than non-cases? The outcome is expressed as an **Odds Ratio**, a form of **Relative Risk**.

Cohort study: A study which follows those with an exposure of interest (usually over a period of years), and compares their incidence of disease or mortality with a second group, who are unexposed or exposed at a lower level. Is the incidence rate higher in the exposed workers than the unexposed/less exposed group? Sometimes the cohort is followed forwards in time ('prospective' cohort study), but sometimes the experience of the cohort is reconstructed from historic records ('retrospective' or 'historic' cohort study). The ratio of risk in the exposed relative to the unexposed can be expressed in various ways, such as a **Relative Risk** or **Standardised Mortality Ratio**.

Measures of association

Statistical significance and P values: Statistical significance refers to the probability that a result as large as that observed, or more extreme still, could have arisen simply by chance. The smaller the probability, the less likely it is that the findings arise by chance and the more likely they are to be 'true'. A 'statistically significant' result is one for which the chance alone probability is suitably small, as judged by reference to a pre-defined cut-point. (Conventionally, this is often less than 5% ($P < 0.05$)).

Relative Risk (RR): A measure of the strength of association between exposure and disease. RR is the ratio of the risk of disease in one group to that in another. Often the first group is exposed and the second unexposed or less exposed. *A value greater than 1.0 indicates a positive association between exposure and disease.* (This may be causal, or have other explanations, such as bias, chance or **confounding**.)

Odds Ratio (OR): A measure of the strength of association between exposure and disease. It is the odds of exposure in those with disease relative to the odds of exposure in those without disease, expressed as a ratio. For rare exposures, odds and risks are numerically very similar, so the OR can be thought of as a **Relative Risk**. *A value greater than 1.0 indicates a positive association between exposure and disease.* (This may be causal, or have other explanations, such as bias, chance or **confounding**.)

Standardised Mortality Ratio (SMR): A measure of the strength of association between exposure and mortality; a form of **Relative Risk (RR)** in which the outcome is death. The SMR is the ratio of the number of deaths (due to a given disease arising from exposure to a specific risk factor) that occurs within

the study population to the number of deaths that would be expected if the study population had the same rate of mortality as the general population (the standard).

By convention, SMRs (and standardised incidence rates (SIR) as described below) are usually multiplied by 100. Thus, an SMR (or SIR) of 200 corresponds to a RR of 2.0. For ease of understanding in this report, SMRs (or SIRs) are quoted as if RRs, and are not multiplied by 100. Thus, *a value greater than 1.0 indicates a positive association between exposure and disease.* (This may be causal, or have other explanations, such as bias, chance or **confounding**.)

Standardised incidence ratio (SIR): An SIR is the ratio of the observed number of cases of disease (e.g. cancer) to the expected number of cases, multiplied by 100. The ratio is usually adjusted to take account of differences in the population evaluated with the comparison or “normal population”, due to age, gender, calendar year, and sometimes geographical region or socioeconomic status.

Other epidemiological terms

Confidence Interval (CI): The **Relative Risk** reported in a study is only an estimate of the true value in the underlying population; a different sample may give a somewhat different estimate. The CI defines a plausible range in which the true population value lies, given the extent of statistical uncertainty in the data. The commonly chosen 95% CIs give a range in which there is a 95% chance that the true value will be found (in the absence of bias and confounding). *Small studies generate much uncertainty and a wide range, whereas very large studies provide a narrower band of compatible values.*

Confounding: Arises when the association between exposure and disease is explained in whole or part by a third factor (confounder), itself a cause of the disease, that occurs to a different extent in the groups being compared.

For example, smoking is a cause of lung cancer and tends to be more common in blue-collar jobs. An apparent association between work in the job and lung cancer could arise because of differences in smoking habit, rather than a noxious work agent. Studies often try to mitigate the effects of (‘control for’) confounding in various ways such as: restriction (e.g. only studying smokers); matching (analyzing groups with similar smoking habits); stratification (considering the findings separately for smokers and non-smokers); and mathematical modelling (statistical adjustment).



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