Exhibit 256

ORIGINAL ARTICLE

Update of mortality and cancer incidence in the Australian petroleum industry cohort

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Objectives: To update the analysis of the cohort mortality and cancer incidence study of employees in the Australian petroleum industry.
Methods: Employees of Australian Institute of Petroleum member companies were enrolled in the cohort in four industry-wide surveys between 1981 and 1999. Mortality of 16 547 males and 1356 females was determined up to 31 December 2001 and cancer incidence to 31 December 2000. Cause specific mortality and cancer incidence were compared with those of the Australian population by means of standardised mortality ratios (SMRs) and standardised incidence ratios (SIRs). Associations between increased incidence of specific cancers and employment in the petroleum industry were tested by trends according to period of first employment, duration of employment, latency, and hydrocarbon exposure, adjusting for personal smoking history where appropriate.
Results: There was a significant elevation of the incidence of mesothelioma (SIR 1.77, 95% CI 1.05 to 2.79), melanoma (SIR 1.37, 95% CI 1.19 to 1.58), and prostate cancer (SIR 1.18, 95% CI 1.04 to 1.34). The SIRs of all leukaemias and of acute non-lymphocytic leukaemia (ANLL) were not significantly different from unity, but all 11 ANLL cases were clustered in the middle to high hydrocarbon exposure categories. Tanker drivers had a significantly elevated incidence of kidney cancer (12 cases *v* 5.84 expected, SIR 2.05, 95% CI 1.06 to 3.59). Lung cancer incidence was significantly reduced (SIR 0.69, 95% CI 0.57 to 0.83)
Conclusions: Most cases of mesothelioma are probably related to past exposure to asbestos in refineries. No occupational cause has been identified for the excess of melanoma, or prostatic or bladder cancer. The possibility of a causal relationship between cancer of the kidney and hydrocarbon exposure warrants further study. It is uncertain whether benzene exposures, particularly past levels of exposure, have been high enough to cause ANLL.

The Australian Petroleum industry surveillance programme *Health Watch* was established in 1980. The cohort remained open to new entrants into the industry until 2000, but has now been closed. The most recent analysis of mortality and cancer incidence in the cohort included deaths and cancers registered up to 31 December 1996.[1] A nested case-control study has also been conducted of the association between leukaemia incidence and benzene exposure.[2] This update covers deaths up to 31 December 2001 and cancers registered up to 31 December 2000.

METHODS

Employees of Australian Institute of Petroleum member companies were first enrolled in the cohort in 1980–83 through a survey interview. At interview, information was obtained on work areas and tasks, and on smoking. Three further surveys were carried out between 1985 and 2000 at which new employees were enrolled and existing cohort members still employed were re-interviewed. Head office staff and those at facilities with fewer than 10 employees were excluded. Interviewees were admitted to the cohort at interview or on completion of five years of service, whichever was the later. Participation was voluntary, and estimated participation rates in the successive surveys were 92%, 92%, 84%, and 73%. Each year member companies provide information on retirements, redundancies, and transfers. Those no longer employed by member companies are followed by periodic mailout to obtain an update of smoking and other information.

Jobs are coded according to the system developed by the American Petroleum Institute.[3 4] Total hydrocarbon exposure was derived from job codes, ranked by a committee of industry occupational hygienists into seven categories of exposure. Jobs not coded are assigned to the default category 4. It is a somewhat crude measure of exposure; a more detailed, quantitative estimate of benzene exposures has been undertaken as part of the nested case-control study of leukaemia cases in the cohort.[5]

Deaths are identified by a search of the National Death Index (NDI) maintained by the Australian Institute of Health and Welfare (AIHW). Registered cancers in cohort members are identified by a search of the National Cancer Statistics Clearing House (NCSCH), a consolidated database from all State and Territory cancer registries; it is searched for cancer registrations maintained by the AIHW, except for cancers registered in the States of Victoria and South Australia,

Table 1 State of the cohort as at 31 December 2001

	Male	Female
Died in Australia	1147	27
Still employed	4976	321
Retired from industry	10204*	935†
Withdrawn‡	220	73
Total	16547	1356
Person-years of follow up	242367	14906
Median employment duration (years)	18	10
Median year of birth	1947	1955

*Includes 23 emigrated and/or died overseas and 608 vital status unknown.
†Includes 3 emigrated and 124 vital status unknown.
‡Employer quit Australian Institute of Petroleum in 1994.

Table 2 Mortality by major cause

	Males		Females	
Cause	Obs/Exp	SMR (95% CI)	Obs/Exp	SMR (95% CI)
Cancer (malignant)	459/553.1	0.83 (0.76–0.91)	18/17.5	1.03 (0.61–1.62)
Ischaemic heart disease	295/389.6	0.76 (0.67–0.85)	6/4.8	1.25 (0.46–2.72)
Stroke	50/79.8	0.63 (0.47–0.83)	0/2.2	
Respiratory disease	79/99.8	0.79 (0.63–0.99)	1/2.3	0.43 (0.01–2.40)
Digestive system diseases	34/64.1	0.53 (0.37–0.74)	0/1.3	
Accidents, violence, etc	100/153.9	0.65 (0.53–0.79)	0/3.1	
All other causes	130/244.7	0.53 (0.44–0.63)	2/6.4	0.31 (0.04–1.14)
All causes	1147/1585.0	0.72 (0.68–0.77)	27/37.6	0.72 (0.47–1.04)

where the cancer registries conduct separate searches. Vital status is also checked by periodic mailouts to subjects, and by searches of the electoral roll and records of the Health Insurance Commission (HIC).

Subjects' follow up time commences on admission to the cohort, which occurs on the date of initial survey interview or on completion of five years of employment in the industry, whichever is the later. Subjects lost to contact are censored from the date of last contact.

Standardised mortality ratios (SMRs) and standardised cancer incidence ratios (SIRs), adjusted by age and calendar year of occurrence by five year groupings, were generated by comparison of mortality and cancer incidence with national rates. Exact 95% confidence intervals were calculated; these do not rely on large numbers for validity.[6 7] Tests for constant SMRs and SIRs across several categories were carried out using Poisson regression.[8]

Cancers with raised SIRs were analysed to detect trends in relation to period of first employment and duration of employment. To allow for uncertainties in latency, estimates were made of variation in incidence with time since first employment. Analyses were also performed for increasing hydrocarbon rank score—both for the highest ranked job ever held, and the rank score of the job held longest. The measure of effect in these analyses was relative incidence ratios (RIR), being the measure relative to a baseline stratum, adjusted by age, calendar year, and, where appropriate, smoking. Poisson regression was used for the relative incidence rate calculations using the method described by Berry[9] and Breslow and Day.[10]

The study was conducted with the approval of the Human Research Ethics Committee of the University of Adelaide, and the ethics committees of all State and Territory cancer registries.

RESULTS

The state of the cohort at 31 December 2001 is shown in table 1. Although 3.6% and 9.1% of males and females respectively were lost to contact as of 31 December 2001, many of these had been found (e.g. in HIC files) relatively recently, so that lost follow up time was only 1.3% in males and 4.9% in females.

Mortality by major cause for both sexes is shown in table 2. The all-cause SMR is significantly below unity in males. In females the SMR was similarly lowered but statistical significance is marginal. Mortality from all major causes in males was significantly below unity. In females, 18 of the 27 deaths were from cancer but the cancer SMR was not significantly raised. Mortality from heart disease was significantly below unity (SMR 0.76, 95% CI 0.67 to 0.85). Ischaemic heart disease mortality was strongly related to the degree of tobacco use, with a more than fourfold increase in those smoking more than 30 cigarettes per day. Mortality from non-malignant respiratory disease, diseases of the digestive system, and poisonings and violence were all significantly less than unity (table 2).

Cancer mortality and cancer incidence in males are shown in table 3. The SIR for all cancers was 1.02 (95% CI 0.96 to 1.08). There were significant excesses of the incidence of mesothelioma (SIR 1.77, 95% CI 1.05 to 2.79), melanoma (SIR 1.37, 95% CI 1.19 to 1.58), and prostate cancer (SIR 1.18, 95% CI 1.04 to 1.34). The incidence of lung cancer was significantly below unity (SIR 0.69, 95% CI 0.57 to 0.83). The all-cancer SMR was significantly less than unity (0.83, 95% CI 0.76 to 0.91). There were no individual cancers for which the SMR significantly exceeded unity, and only one cancer in which the SMR was significantly less than unity, viz. lung cancer (0.62, 95% CI 0.50 to 0.76).

Two of the 18 mesotheliomas were peritoneal; 15 of the 18 cases occurred in refinery workers.

Both lung cancer incidence and lung cancer mortality were significantly reduced in comparison with the general male population. Nevertheless lung cancer was the largest individual cause of cancer mortality in the cohort (93 deaths). There was a strong association between smoking and lung cancer incidence. There was a 17-fold increase in risk in those smoking up to 19 cigarettes per day compared with the risk in those who have never smoked, a 22-fold increase in risk for those who smoke 21–30 cigarettes per day, and a 43-fold increase in risk for those who smoke more than 30 cigarettes per day. Ex-smokers had a fivefold increase in risk. There were only four lung cancers among lifelong non-smokers (4 per 77 507 person-years).

To test for a relative excess of lung cancer in refinery maintenance workers, the incidence was compared with refinery non-maintenance workers, with office workers excluded. The incidence relative to non-maintenance workers, after adjusting for smoking, was 1.10 (95% CI 0.47 to 2.64).

The incidence of melanoma was significantly raised overall, and the excess was significantly increased in refinery and terminal personnel. There was no significant association with decade of hire, duration of employment, time since hire, or hydrocarbon exposure ranking. Despite the excess incidence the mortality rate from melanoma was not significantly different from that of the general population (SMR 0.91, 95% CI 0.55 to 1.53).

Prostatic cancer was the commonest cancer in males (251 cases), and the incidence was significantly elevated (SIR 1.18, 95% CI 1.04 to 1.34). There were only 35 deaths from prostatic cancer, and the mortality rate was not significantly different from that of the general population (SMR 0.94, 95% CI 0.65 to 1.30). The incidence was raised in all categories of workplace type except for airport personnel, but the excess is not significant in any of them. There was no trend in prostatic cancer incidence with period of first employment, duration of employment, time since hire, or increasing rank of hydrocarbon exposure.

Table 3 Cancer incidence and mortality in males

	Cancer incidence		Cancer mortality	
	Obs/Exp	SIR (95% CI)	Obs/Exp	SMR (95% CI)
Lip, oral cavit,y and pharynx	55/73.0	0.75 (0.57–0.98)	8/19.3	0.41 (0.18–0.81)
Oesophagus	11/18.3	0.60 (0.30–1.08)	13/19.1	0.68 (0.36–1.16)
Stomach	35/35.9	0.97 (0.68–1.35)	19/22.9	0.83 (0.50–1.29)
Colorectal	186/179.8	1.03 (0.89–1.19)	63/74.8	0.84 (0.65–1.08)
Liver	8/12.2	0.66 (0.28–1.30)	10/12.9	0.78 (0.37–1.43)
Gallbladder	5/6.7	0.75 (0.24–1.75)	3/3.5	0.86 (0.18–2.51)
Pancreas	23/23.6	0.97 (0.62–1.46)	22/24.6	0.89 (0.56–1.35)
Larynx	18/20.9	0.86 (0.51–1.36)	6/8.0	0.75 (0.27–1.62)
Lung	113/163.8	0.69 (0.57–0.83)	93/149.0	0.62 (0.50–0.76)
Melanoma	191/139.0	1.37 (1.19–1.58)	19/20.8	0.91 (0.55–1.43)
Non-melanotic skin			3/5.7	0.52 (0.11–1.52)
Mesothelioma	18/10.2	1.77 (1.05–2.79)		
Connective tissue	5/8.8	0.57 (0.18–1.32)	3/3.5	0.87 (0.18–2.53)
Prostate	251/212.5	1.18 (1.04–1.34)	35/37.3	0.94 (0.65–1.30)
Testis	19/14.3	1.33 (0.80–2.08)	1/1.0	1.01 (0.03–5.63)
Bladder	60/51.4	1.17 (0.89–1.50)	9/11.1	0.81 (0.37–1.53)
Kidney	45/39.1	1.15 (0.84–1.54)	14/14.7	0.95 (0.52–1.60)
Eye	5/4.0	1.24 (0.40–2.90)		
Brain and nervous system	21/23.9	0.88 (0.54–1.34)	24/22.1	1.08 (0.70–1.61)
Non-Hodgkin's lymphoma	48/54.0	0.89 (0.66–1.18)	22/22.2	0.99 (0.62–1.50)
Multiple myeloma	16/14.0	1.14 (0.65–1.85)	12/8.6	1.39 (0.72–2.42)
Leukaemia	34/31.9	1.07 (0.74–1.49)	18/18.2	0.99 (0.59–1.56)
Acute lymphatic leukaemia	3/1.8	1.70 (0.35–4.97)	2/1.6	1.24 (0.15–4.48)
Chronic lymphatic leukaemia	12/11.7	1.03 (0.53–1.79)	1/3.3	0.30 (0.01–1.67)
Acute myeloid leukaemia	8/8.3	0.97 (0.42–1.91)	6/8.2	0.73 (0.27–1.59)
Chronic myeloid leukaemia	5/4.6	1.09 (0.36–2.55)	4/2.8	1.45 (0.39–3.70)
Other leukaemia	6/5.6	1.07 (0.39–2.33)	5/2.3	2.21 (0.72–5.15)
Acute non-lymphocytic leukaemia	11/10.4	1.06 (0.53–1.90)	6/9.0	0.66 (0.24–1.45)
Other and unspecified sites	66/73.0	0.90 (0.70–1.15)	62/40.2	1.54 (1.18–1.98)
Total	1232/1210.5	1.02 (0.96–1.08)	459/553.1	0.83 (0.76–0.91)

There were 60 bladder cancers in males. Whereas the previous update of this cohort showed a significant excess of bladder cancer,[1] in this analysis the incidence was not significantly raised (SIR 1.17, 95% CI 0.89 to 1.50). There were only nine deaths from bladder cancer, fewer than expected on the basis of population rates, but the difference is not statistically significant (SMR 0.81, 95% CI 0.37 to 1.53). Bladder cancer did not occur in significant excess in any workplace type, and there was no trend in incidence with period of first employment, duration of employment, or time since hire; nor was there any trend in incidence with hydrocarbon exposure ranking. There were two bladder cancers in women.

There were 34 leukaemia cases in males (SIR 1.07, 95% CI 0.74 to 1.49). In all individual leukaemia subtypes the rate was close to the population rate except for acute lymphatic leukaemia, where the SIR was 1.70 (95% CI 0.35 to 4.97) based on only three cases. Mortality from leukaemia was similar to the population rate (SMR 0.99, 95% CI 0.59 to 1.56).

There were 11 acute non-lymphocytic leukaemias (10.4 expected, SIR 1.06, 95% CI 0.53 to 1.90). Table 4 shows the distribution of the 11 cases according to category of hydrocarbon exposure. The cases were clustered in the middle to upper level exposure categories; there were no cases in the three lowest exposure categories in either table. Table 5 shows the period of first employment of the ANLL cases. Five of the 11 cases were first hired before 1955.

There was a small but statistically significant increase in all-cancer incidence in drivers (SIR 1.15, 95% CI 1.00 to 1.32). However, the only cancer in significant excess in drivers was cancer of the kidney (12 cases *v* 5.84 expected, SIR 2.05, 95% CI 1.06 to 3.59). Because there were only 12 cases, and since all drivers are ranked in category 6 of hydrocarbon exposure, it is not possible to conduct a meaningful analysis of trend with hydrocarbon exposure. The SIR for cancer of the kidney for the whole cohort was 1.15 (95% CI 0.84 to 1.54).

DISCUSSION

Participation in *Health Watch* is voluntary, but the high participation rates, especially in the first two surveys (93%), make volunteer bias very unlikely. The relatively low participation rate in the fourth survey (estimated at 73%) resulted in a lack of recruits to the cohort from offshore

Table 4 ANLL incident cases by total hydrocarbon (HC) exposure

	Highest HC ranking job		HC ranking longest job	
Exposure category	Person-years	Cases	Person-years	Cancer
1	41478	0	57030	0
2	20113	0	21560	0
3	2485	0	3721	0
4	104602	7	96148	7
5	8405	1	5997	1
6	36634	2	57030	3
7	13365	1	21560	0

Table 5 ANLL incidence by period of first employment, adjusted for age and calendar period of follow up

Period of first employment	Person-years	Cancer	RIR	95% CI
Post-1975	110369	4	1.00	
1965–74	72615	2	0.28	0.05–1.71
1955–64	29932	0	–	–
Pre-1955	14259	5	1.62	0.20–13.29

production, but did not significantly alter the composition of the cohort: 4.0% of the cohort were in the offshore production sector prior to the fourth survey, and 3.7% after it.

A potential weakness of the study is that subjects' date of hire is obtained from subjects at the time of interview. Nevertheless any resulting error is likely to be random and hence unlikely to lead to bias. Moreover errors from imperfect recollection of the year of hire are likely to be small in relation to the size of time related categories (e.g. period of employment categories are pre-1954, 1955–64, 1965–74, and post-1975).

Identification of cancer is a strength of the study as cancer registration is mandatory in all Australian States and Territories, and registration is virtually complete. However, complete matching cannot be guaranteed, and some missed cases were identified when reconciling information from the NCSCH with the state cancer registries which supply the information to it. Seven cancers not found in the NCSCH were excluded from the analysis, since for a valid comparison of cancer incidence with the general population, cancer registrations in the *Health Watch* cohort must also appear in the NCSCH data (from which national cancer incidence tables are derived).

The occurrence of 18 cases of mesothelioma is indicative of asbestos exposure, and is consistent with the findings of other studies in oil refinery workers.[11–13] It is likely that some of these cases are attributable to asbestos exposure prior to entering the petroleum industry.

Although smoking prevalence in the cohort is similar to that of the general population, the lung cancer rate is significantly reduced. A possible explanation for the low lung cancer incidence may be differences in the amount smoked, i.e. smokers in the petroleum industry smoke less, and ex-smokers quit sooner, than smokers in the general population; lung cancer incidence is very sensitive to these variables.[14]

The relatively low incidence of lung cancer suggests that there are few, if any, such cancers caused by asbestos. Detailed analyses of asbestos related conditions will be given in a separate paper.

Leukaemia has been a disease of special concern in this industry because of its association with benzene exposure. Although earlier analyses of this cohort showed an excess of leukaemia incidence, subsequent updates have shown a declining SMR, and there is now no significant excess of leukaemias in the *Health Watch* cohort. Moreover, internal analysis within the cohort shows no significant trend in leukaemia incidence with duration of employment or with increasing hydrocarbon exposure. This finding is not unexpected, since ''leukaemia'' is not a single disease, but a composite of leukaemia types which are in fact different disease entities. Acute non-lymphocytic leukaemia (ANLL) is the only leukaemia subtype likely to be causally related to benzene exposure.[15]

Overall there was no excess of ANLL (11 cases observed and 10.35 expected). While this may suggest that benzene exposures in this industry may be too low to cause a detectable increase in the incidence of ANLL, it should be noted that all 11 cases were clustered in the medium to higher categories of hydrocarbon exposure; that is, there are no cases at all in the three lowest exposure categories. It is possible that the absence of any cases in the low exposure categories could be due to errors in classification. The method of exposure categorisation is a somewhat crude index of exposure. Many tasks in the industry have not been assigned an exposure category, and are assigned to the default category 4 (out of 7), which is accordingly the largest category in terms of follow up, and with the largest number of leukaemia cases. Nevertheless the analyses of ANLL by hydrocarbon exposure are similar to that of the *Health Watch* case-control study, in which careful estimates of benzene exposure were made.[5] This suggests that misclassification bias has not contributed significantly to the findings of the internal analyses.

Other cohort studies in this industry have not found an excess of mortality from ANLL.[16] A Canadian cohort study found a marginally significant excess mortality from ANLL, but most of the excess was in office workers.[17] A later update of this cohort showed no increase in ANLL incidence or mortality.[18] In a case-control study of petroleum marketing and distribution workers in the UK, the authors concluded that there was some suggestion of a relation between exposure to benzene and myeloid leukaemia, particularly acute myeloid leukaemia.[19] A case-control study nested within the Canadian cohort in 1996 has shown no association between increasing benzene exposure and risk of leukaemia.[20] On the other hand the case-control study from the *Health Watch* cohort has found a strong association with increasing benzene exposure. Moreover the benzene exposure levels in the *Health Watch* case-control studies were in general lower than in the UK and Canadian studies.[2] The findings of the cohort study indicate that, at most, only a very small number of workers in this industry have developed ANLL from benzene exposure.

The significance of the excess melanoma incidence is not clear, but no causal association with any exposure in the workplace is apparent since there is no tendency for increasing risk with increasing duration of employment, and risk shows no relationship to hydrocarbon exposure. Melanoma incidence is strongly affected by intensity of medical surveillance. The low mortality rate (SMR 0.90, 95% CI 0.50 to 1.48) is consistent with early recognition as the cause of the raised incidence rate. However an analysis of staging of melanomas in *Health Watch* subjects registered in the NSW Cancer Registry showed that melanomas were not being diagnosed at an earlier stage than melanomas in the general NSW population. Some excesses of melanoma mortality and incidence have been reported in this industry, but no occupational cause is apparent.[21–23] Apart from the well established association with exposure to solar radiation, melanoma has a tendency to occur in higher socioeconomic groups.[24] There is no reason to suspect either factor being of special significance in this cohort, which has mostly excluded senior management.

Similarly there is no evidence linking the excess of prostatic cancer to any occupational factor.

Main messages

- There is a significant excess of mesothelioma in the Australian petroleum industry cohort.
- Tanker drivers have a significantly elevated incidence of kidney cancer.
- It is uncertain whether benzene exposures, particularly past levels of exposure, have been high enough to cause leukaemia. At most, only a very small number of workers in this industry have developed ANLL from benzene exposure.

Policy implications

- It is unlikely that asbestos exposures such as in the 1950s and 1960s have occurred in recent years. Nevertheless mesotheliomas can follow quite low exposures, and it is important that exposures from any residual asbestos in refineries be eliminated.
- The possibility of a causal relationship between cancer of the kidney and hydrocarbon exposure warrants further study.

Bladder cancer was found in significant excess in the previous analysis, but in this analysis the excess was found to be less and non-significant (SIR 1.17, 95% CI 0.89 to 1.50). Bladder cancer mortality was not elevated. An increased risk of bladder cancer mortality has not been noted in this industry, and in the only other cancer incidence study in the industry no excess of bladder cancers was found.[18]

Although the incidence of cancer of the kidney was not raised in the cohort as a whole, the incidence was statistically elevated in drivers. Since there were only 12 cases, meaningful analyses of incidence by time related factors were not possible, and analyses by hydrocarbon exposure ranking is not possible because drivers are all given the same exposure ranking (category 6). However in the cohort *as a whole* there was a significant trend of increasing relative incidence rate of kidney cancer with increasing hydrocarbon exposure ranking, even though the incidence of kidney cancer was not significantly elevated. In the whole cohort there was no trend to increasing incidence with increasing employment time.

There is limited prior evidence to suggest a possible link between kidney cancer and hydrocarbon exposure. A population based case-control study published in 1989 found a weak positive association between renal cell carcinoma and hydrocarbon exposure was found in males only.[25] Another population based case-control study based on incident cases in the Danish Cancer Registry found a twofold increase in risk of renal cell carcinoma in workers occupationally exposed to gasoline (odds ratio 2.1, 95% CI 1.1 to 4.1).[26] In a 1993 report of Canadian petroleum distribution workers (which includes drivers), a non-significant excess mortality from kidney cancer (SMR 135) was found. Those exposed to hydrocarbons daily had a relative risk of mortality from kidney cancer of 3.80, although the excess was not statistically significant.[27] In another study of UK distribution workers, the SMR for kidney cancer in drivers was 141. Fifteen of the 25 deaths were in drivers with more than 20 years' service, but the excess was not statistically significant.[28] Other mortality studies in the petroleum industry have not noted an increase in cancers of the kidney,[22] and the only other cohort study of cancer incidence in this industry found no excess of kidney cancer.[18] The possibility of an association between cancer of the kidney and hydrocarbon exposure warrants further study, particularly in future studies of cancer incidence.

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REFERENCES

1 **Gun RT**, Pratt NL, Griffith EC, *et al*. Update of a prospective study of mortality and cancer incidence in the Australian petroleum industry. *Occup Environ Med* 2004;**61**:150–6.
2 **Glass DC**, Gray CN, Jolley DJ, *et al*. Leukaemia risk associated with low-level benzene exposure. *Epidemiology* 2003;**14**:569–77.
3 **Tabershaw Occupational Medicine Associates**. *Job code classification system: Part 1—Petroleum refineries and selected petrochemical operations*. Washington: API, 1979.
4 **American Petroleum Institute OH Industrial Hygiene Sub-Committee**. *Job code classification system: Part II—Production operations and marketing/ transportation operations*. Washington: API, 1985.
5 **Glass DC**, Gray CN. Estimating mean exposures from censored data: exposure to benzene in the Australian petroleum industry. *Ann Occup Hyg* 2001;**45**:275–82.
6 **Pearson ES**, Hartley HO. *Biometrika tables for statisticians (vol. 1)*. Cambridge University Press, 1956.
7 **Liddell FDK**. Simple exact analysis of the standardised mortality ratio. *J Epidemiol Community Health* 1984;**38**:85–8.
8 **Breslow NE**, Lubin JH, Marek P, *et al*. Multiplicative models and cohort analysis. *J Am Stat Assoc* 1983;**78**:1–12.
9 **Berry G**. The analysis of mortality by the subject-years method. *Biometrics* 1983;**39**:173–84.
10 **Breslow NE**, Day NE. *Statistical methods in cancer research: Vol. II—The design and analysis of cohort studies*. Lyon: IARC, 1987.
11 **Gennaro V**, Finkelstein M, Ceppi M, *et al*. Mesothelioma and lung tumours attributable to asbestos among petroleum workers. *Am J Ind Med* 2000;**37**:275–82.
12 **Gennaro V**, Ceppi M, Boffetta P, *et al*. Pleural mesothelioma and asbestos exposure among Italian oil refinery workers. *Scand J Work Environ Health* 1994;**20**:213–15.
13 **Tsai SP**, Waddell LC, Gilstrap EL, *et al*. Mortality among maintenance employees potentially exposed to asbestos in a refinery and petrochemical plant. *Am J Ind Med* 1996;**29**:89–98.
14 **Peto R**, Deo H, Silcocks P, *et al*. Smoking, smoking cessation, and lung cancer in the UK since 1950; a combination of national statistics with two case-control studies. *BMJ* 2000;**321**:323–9.
15 **Sorahan T**, Kinlen LJ, Doll R. Cancer risk in a historical cohort of benzene exposed workers. *Occup Environ Med* 2005;**62**:231–6.
16 **Wong O**, Raabe GK. Cell-type-specific leukemia analyses in a combined cohort of more than 208,000 petroleum workers in the United States and the United Kingdom, 1937–1989. *Regul Toxicol Pharmacol* 1995;**21**:307–21.
17 **Lewis RJ**, Schnatter AR, Katz AM, *et al*. Updated mortality among diverse operating segments of a petroleum company. *Occup Environ Med* 2000;**57**:595–604.
18 **Lewis RJ**, Schnatter AR, Drummond I, *et al*. Mortality and cancer morbidity in a cohort of Canadian petroleum workers. *Occup Environ Med* 2003;**60**:918–28.
19 **Rushton L**, Romaniuk H. A case-control study to investigate the risk of leukaemia associated with exposure to benzene in petroleum marketing and distribution workers in the United Kingdom. *Occup Environ Med* 1997;**54**:152–66.
20 **Schnatter AR**, Armstrong TW, Thompson LS, *et al*. The relationship between low-level benzene exposure and leukemia in Canadian petroleum distribution workers. *Environ Health Perspect* 1996;**104**(suppl 6):1375–9.
21 **Rushton L**. Further follow up of mortality in a United Kingdom oil refinery cohort. *Br J Ind Med* 1993;**50**:549–60.

22 **Wong O**, Raabe GK. A critical review of cancer epidemiology in the petroleum industry, with a meta-analysis of a combined database of more then 350000 workers. *Reg Tox Pharmacol* 2000;**32**:78–98.
23 **Lewis RJ**, Schnatter AR, Drummond I, *et al*. Mortality and cancer morbidity in a cohort of Canadian petroleum workers. *Occup Environ Med* 2003;**60**:918–28.
24 **Lewis N**, Nguyen H, *et al. Cancer maps for New South Wales; variation by Local Government Area 1991 to 1995*. Cancer Epidemiology Research Unit and the NSW Central Cancer Registry, March 1999. www.nswcc.org.au.
25 **Kadanami S**, Asal NR, Nelson RY. Occupational hydrocarbon exposure and risk of renal cell carcinoma. *Am J Ind Med* 1989;**15**:131–41.
26 **Mellemgaard A**, Engholm G, McLaughlin JK, *et al*. Occupational risk factors for renal-cell carcinoma in Denmark. *Scan J Work Environ Health* 1994;**20**:160–5.
27 **Schnatter AR**, Katz AM, Nicolich MJ, *et al*. A retrospective mortality study among Canadian petroleum marketing and distribution workers. *Environ Health Perspect Suppl* 1993;**101**(suppl 6):85–99.
28 **Rushton L**. A 39-year follow-up of the UK oil refinery and distribution center studies: results for kidney cancer and leukaemia. *Environ Health Perspect Suppl* 1993;**101**(suppl 6):77–84.