precipitation and alkali unwinding assays for detecting DNA strand breaks and cross-links. *Cancer Res* 1988, **48**, 6444–6449.

58. Hagen UFW. Measurement of strand breaks by end labelling. In: Friedberg EC, Hanawalt PC, eds. *DNA Repair: A Laboratory Manual of Research Procedures*. New York, Marcel Dekker, 1981, Vol. 1, part B, 431–445.
59. Smeets M, Slebos R, Stoker K and Begg AC. Attempts to measure DNA double-strand breaks using molecular biological methods. *Int J Radiat Biol* 1990, **57**, 1254.
60. Wun KLW, Schafer RH. Structural changes in mammalian cell DNA induced by low dose X-ray damage and subsequent postirradiation incubation in the presence and absence of caffeine. *Radiat Res* 1982, **90**, 310–320.
61. Karam LR, Calsou P, Franklin WA, Painter RB, Olsson M, Lindahl T. Modification of deoxyribose-phosphate residues by extracts of ataxia telangiectasia cells. *Mutat Res* 1990, **236**, 19–26.
62. Srinivasan S, Glauert HP. Formation of 5-hydroxymethyl-2′-deoxyuridine in hepatic DNA of rats treated with gamma-irradiation, diethylnitrosamine, 2-acetylaminofluorene or the peroxisome proliferator ciprofibrate. *Carcinogenesis* 1990, **11**, 2021–2024.

Acknowledgements—The authors are grateful to Gordon Steel and John Peacock for comments on this manuscript. The authors are funded by the Cancer Research Campaign and the Bob Champion Trust, Royal Marsden Hospital.

Eur J Cancer, Vol. 27, No. 7, pp. 928–931, 1991.
Printed in Great Britain

0277–5379/91 $3.00 + 0.00

Cancer Incidence in New South Wales, Australia

Margaret McCredie, Marylon Coates, Tim Churches and Richard Taylor

In 1972, cancer registration began in New South Wales (NSW), the most populous state in Australia. The operations of the Registry are described. By 1990, approximately 316 000 new cases of cancer had been notified from a population that had increased from 4.6 to 5.8 million. In 1981–1984, the most common sites in men were lung, prostate, colon, melanoma and bladder, and in women, breast, melanoma, colon, lung and unknown primary site. Cancers which, between 1973–1976 and 1981–1984, had increased in reported incidence by more than 25% were pharynx and kidney in both sexes, rectum, testis and melanoma in men, and lung and bladder in women; those decreasing by more than 10% were stomach in both sexes, oesophagus in men and cervix in women. Age-standardised incidence rates for melanoma (27.4 [m] and 23.8 [f] per 100 000 in 1987) and cancer of the renal pelvis in women (1.7 per 100 000 in 1989) are among the highest in the world.
Eur J Cancer, Vol. 27, No. 7, pp. 928–931, 1991

INTRODUCTION

New South Wales (NSW) is the most populous of the six federated states of Australia. In 1971 the NSW Central Cancer Registry was established to collect statistics for the state from January 1972. NSW, a temperate zone between 28° and 38° south and 141° and 154° east, has an area of 801 400 square kilometres excluding the Australian Capital Territory which is bordered on all sides by NSW. The population, in millions, was 4.6 in 1972, 5.4 in 1984 and 5.8 in 1990. In 1984, 31% of the population was aged less than 20 years and 11% 65 years or over. A coastal population predominates, 76% living in the Sydney–Newcastle–Wollongong conurbation along the central coast. At the 1986 census, 89% of the population lived in urban areas and 22% were born overseas.

This report presents a description of the operation of the Registry, and for the period 1972–1984, a summary of cancer incidence in NSW, indicating the most common cancers and those sites which have changed most over time. More recent data are presented for melanoma and cancer of the renal pelvis, sites which are particularly common in New South Wales.

OPERATION OF THE REGISTRY

Type of data

All new cases of cancer in residents of NSW are notified to the Registry, exceptions being basal and squamous cell carcinomas of the skin and *in situ* cancers at any site. Information is collected relating to identifying and demographic characteristics, and to the diagnosis of cancer but not to risk factors for cancer, such as occupation or smoking habits.

In the period 1972–1984, most cases were verified histologically (average for all cancers combined was between 87% and 92%) and less than 1% of cases were reported by death certificate only.

Sources of data

The main source of data is the compulsory notification form completed by medical or records staff for each admission of a patient with cancer to every hospital, both public and private, and nursing home. In addition, each radiotherapy department must notify the first attendance each year of each cancer case. Other sources of data are pathology reports relating to cancer received from all major hospitals and private pathology laboratories, voluntarily up to 1985 and then as a legal requirement. Since 1972, the Registrar-General's Department has supplied listings of all deaths certified as having cancer as the primary cause, with supplementary listings of cancer as the secondary cause from 1978. Tapes of death from all causes have been supplied from 1985, and direct computer matching will be carried out against Registry files. In 1990, there are approximately 308 000 persons registered representing 316 000 new cases of cancer.

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Revised and accepted 4 Feb. 1991.

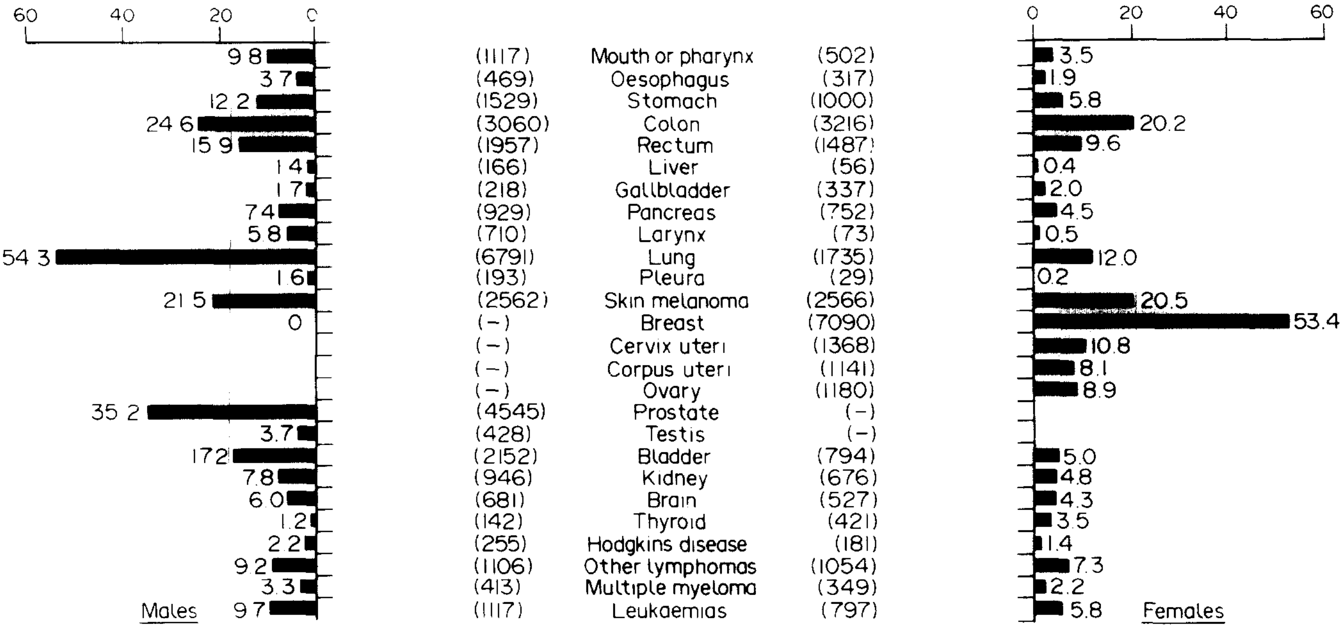

Fig. 1. Age standardised (world) incidence rates from major cancer sites, New South Wales, Australia, 1972–1984. No. of registered cases is given in parentheses.

Data processing

Notifications, pathology reports and death certificates are linked and an interactive search on name (including similar sounding names) and sex is carried out to determine whether or not the person has already been registered. Data are entered either interactively or in an overnight batch program with new registration numbers assigned by computer. Several computer matching programs are run at regular intervals to detect double registrations. A more sophisticated probablistic record linkage program is currently being developed to aid this process and for receipt of notifications in electronic form.

Registration, classification of non-medical data, and the keeping of manual and some computer systems, are the responsibility of clerical staff. For the data presented here, disease classification — topography and morphology — had been carried out by medical staff, who sought advice from specialist pathologists and clinicians as necessary. Currently, coding is done by trained medical records administrators under the supervision of medical specialists.

All documents relating to a single person are linked and stored in alphabetical sequence by full name. At the beginning of 1986, the data were transferred from a simple sequential computer file containing limited information and accessed by batch processing only, to a relational database with immediate and flexible access to any desired combination of fields. The new database allows storage of all details collected on the standard notification form and of thickness for melanoma (available only from pathology reports).

Use of data

Registry records are used to produce descriptive statistics based on age and sex [1–5], to respond to *ad hoc* requests [6, 7] from the community, research, educational and industrial sources and in undergraduate and postgraduate teaching with emphasis on cancer epidemiology. The Registry serves as a central source of case follow-up for institutions, clinics and research workers, and as a resource for planning of hospital, radiotherapy and palliative care services.

Examination of data held in the Registry has included analyses of particular cancer sites [8–13], of trends in incidence over time [14], and of incidence by country of birth [15–19] and by region of residence within NSW [20].

The Registry has collaborated in a case-control study examining the relationship between the habits of excessive analgesic consumption and smoking and the risk of cancer of the kidney and urinary tract [21–26] and is currently participating in international case-control studies investigating the aetiology of childhood brain tumours and renal cell cancer. Other projects include (i) follow-up of cohorts of asbestos, uranium and coal miners; (ii) participation in the evaluation of screening by mammography and cervical cytology in NSW; (iii) a familial melanoma register; and (iv) the incidence of cancer in Italian migrants.

SUMMARY OF CANCER INCIDENCE IN NSW

During 1972–1984, 183 547 new cases of cancer were notified to the Registry. As 1972 was the first year of operation, data for this year have been excluded from the present analysis because of the possibility of under- or over-reporting. Age and sex-specific numbers of cancers, analysed according to the 9th Revision of the International Classification of Diseases (ICD-9) [27] have been used for three 4-year periods, 1973–1976, 1977–1980 and 1981–1984, with estimated resident populations for NSW [28] to produce rates which have been directly standardised to the "World" population [29] (Fig. 1).

Between 1973–1976 and 1981–1984, cancer at all sites increased from 246.0 to 283.4 per 100 000 in men and from 197.4 to 215.3 per 100 000 in women (Table 1). In each period, the five leading sites in men remained the same, namely, lung, prostate, colon, melanoma and bladder. Breast, colon and melanoma were the most common cancers in women throughout the period, but the next most frequent sites in 1973–1976, cervix and ovary, had been replaced in 1981–1984 by lung and unknown primary site.

Cancers which, between 1973–1976 and 1981–1984, had increased in incidence by more than 25% were pharynx, thyroid, kidney, myeloma and those of unknown primary site in both sexes; rectum, liver, testis, and melanoma in men; and lung and bladder in women. Those decreasing by more than 10% were stomach in both sexes, oesophagus in men and cervix in women.

Table 1. Percentage change in age-standardised incidence rates (per 100 000) of selected cancer sites between 1973–1976 and 1981–1984, New South Wales*

		Men			Women		
Site	ICD-9	1973–1976	1981–1984	% change	1973–1976	1981–1984	% change
Lip	140	4.7	4.2	−9.8	0.8	0.7	−7.2
Mouth	141–145	5.2	5.5	+5.4	2.1	2.4	+11.8
Pharynx	146–149	2.9	4.3	+46.1	0.7	1.1	+68.3
Oesophagus	150	4.3	3.7	−13.8	1.9	1.9	−0.1
Stomach	151	13.5	12.2	−10.0	6.7	5.8	−13.2
Colon	153	20.6	24.6	+19.2	17.4	20.2	+15.9
Rectum	154	12.5	15.9	+26.5	8.6	9.6	+12.0
Liver	155	1.0	1.4	+35.4	0.4	0.4	−11.1
Gallbladder	156	1.6	1.7	+11.7	2.0	2.0	+0.5
Pancreas	157	7.7	7.4	−4.6	4.7	4.5	−4.4
Larynx	161	4.7	5.8	+24.0	0.4	0.5	+18.5
Lung	162	51.7	54.3	+5.0	8.4	12.0	+43.2
Melanoma	172	17.1	21.5	+25.3†	19.1	20.5	+7.5†
Breast	174				52.6	53.4	+1.5
Cervix	180				12.5	10.8	−13.3
Uterus	182				7.9	8.1	+2.5
Ovary	183				8.9	8.9	−0.8
Prostate	185	29.7	35.2	+18.6			
Testis	186	2.9	3.7	+28.4			
Bladder	188	14.3	17.2	+20.7	3.9	5.0	+28.6
Kidney	189	5.8	7.8	+35.4	3.4	4.8	+40.9
Brain	191	5.4	6.0	+9.9	3.7	4.3	+15.9
Thyroid	193	0.9	1.2	+40.6	2.2	3.5	+54.5
Unknown primary	199	9.3	15.3	+64.2‡	5.6	10.9	+93.4‡
Lymphomas	200–202	9.5	11.4	+19.1	7.1	8.7	+22.5
Myeloma	203	2.3	3.3	+41.0	1.7	2.2	+26.4
Leukaemias	204–208	8.6	9.7	+12.8	5.5	5.8	+5.3
All sites	140–208	246.0	283.4	+15.2	197.4	215.3	+9.0

*Standardised to "World" population.
†Known to be under-reported in each period.
‡Known to be affected by changing clinical practice (see [14]).

Breast cancer rates were relatively stable and lung cancer in men increased by only 5% during this period.

Whether these trends have been affected by systematic bias due to improvement in reporting to the Registry or changing diagnostic or clinical practices has been discussed [14]. The directions of the trends in this analysis are identical to those for cancer mortality in Australia from 1975–1979 to 1980–1984 [30] with the exception of testicular and bladder cancer. Similar trends for most of these sites have been reported in other Western countries [31, 32], possible exceptions being thyroid cancer and multiple myeloma (neither of which were included in the mortality report [30]). In respect of liver cancer, the NSW Registry has excluded ICD-9 155.2 "liver not specified as primary or secondary", the probable source of the increase in this cancer in Australian mortality [30].

Cancer at all sites was more common in metropolitan (287.2 [m] and 216.0 [f] per 100 000) than non-metropolitan NSW (252.2 and 195.1 per 100 000) in 1979–83 [20]. Urban/rural differences remained in both sexes when all cancers known to be associated with smoking [33] were omitted. However rural rates (80–90% of urban rates for cancer at most of the major sites) may be due, at least in part, to a consistent bias (such as under-reporting or country patients giving a city address when attending hospital for treatment) rather than environmental exposures or lifestyle factors. The only individual site not conforming to this pattern was lip cancer (metropolitan: 3.7 [m] and 0.6 [f] per 100 000; non-metropolitan: 6.2 and 1.1), higher country rates presumably reflecting a predominantly outdoor lifestyle and consequent higher lifetime exposure to ultraviolet radiation.

Distinctive findings in the analysis of migrants to NSW were the high incidence, relative to the Australian-born, of bladder cancer in male immigrants from the British Isles, Europe and the Middle East, of nasopharyngeal cancer in migrants from Southern Europe and of adenocarcinoma of the lung in women born in China [15,17–19].

Cancer particularly common in NSW

Because melanoma can be treated without an admission to hospital, and notification through pathology departments was voluntary until 1985, there has been known under-reporting of this cancer. However, a concerted effort is being made to rectify this problem and the standardised incidence rates for 1987 for melanoma are 27.4 and 23.8 per 100 000 for men and women respectively. Male rates are particularly high after the age of 50 years, being almost double those for women in the oldest age groups. For comparison, the highest rates published for 1978–1982 in *Cancer Incidence in Five Continents* were for

Queensland (30.9 [m] and 28.5 [f] per 100 000) and the white population in Hawaii (22.7 and 18.8) [32]. Melanoma rates are higher among native-born Australians than any migrant group in NSW [15–19], supporting the hypothesis that sun damage to the skin at an early age is an important risk factor. While there is as yet no reliable evidence for trends in the incidence of melanoma in NSW, mortality rates have increased by almost 50% between 1972 and 1987 in men (4.0 to 5.5 per 100 000) but not in women (2.4 per 100 000 in both years; age-standardised from data provided by the Australian Bureau of Statistics).

Incidence rates for cancer of the renal pelvis have been increasing at the rate of 5.5% per year in NSW [13], preliminary rates for 1989 being 1.2 [m] and 1.7 [f] per 100 000. Excessive consumption of phenacetin-containing analgesics, which has been common in NSW, especially amongst women [34], increases the risk for renal pelvic cancer some 8-fold [22,23]. Other populations known to have had a high prevalence of analgesic abuse also have a high incidence of this cancer in women (1978–1982: Denmark 1.0; Basel 1.1; Zurich 1.3; Queensland 1.3 per 100 000) [32].

While undoubtedly the total cancer burden in NSW will increase further due to the aging population, there is some evidence that overall cancer rates are not rising, and for some important sites may be falling, in persons aged less than 50 years [14].

1. *Cancer in NSW. Incidence and Mortality*. Continuing series — 1972 to 1984.
2. Ford JM. Cancer registries in Australia. In: *Epidemiology and Cancer Registries in the Pacific Basin*. NCI Monogr 1977, **47**, 33–35.
3. Ford JM. Australia, New South Wales. In: Waterhouse J, Muir C, Shanmugaratnam K, Powell J. eds. *Cancer Incidence in Five Continents*. Vol IV. IARC Scientific Publication No 42, Lyon, IARC, 1982.
4. Ford JM. Australia, New South Wales. In: Muir C, Waterhouse J, Mack T, Powell J, Whelan S. eds. *Cancer Incidence in Five Continents*. Vol V. IARC Scientific Publication No 88, Lyon, IARC 1987.
5. Ford JM. New South Wales Cancer Registry, 1972–1982. In: Parkin DM, Stiller CA, Draper GJ, Bieber CA, Terracini B, Young JL. eds. *International Incidence of Childhood Cancer*. IARC Scientific Publication No 87, Lyon, IARC, 1988.
6. Richards G, Ford J. Cancer mortality in selected New South Wales localities with fluoridated and non-fluoridated water supplies *Med J Aust* 1979, **2**, 521–523.
7. MacLennan R, Ford J, Coates M. Cancer in the Blue Mountains of New South Wales. *Med J Aust* 1982, **2**, 319–324.
8. Coates MS, Ford JM. Skin cancer in New South Wales. *Trans Menzies Found* 1989, **15**, 149–152.
9. McCredie M, Coates MS, Ford JM. Trends in invasive cancer of the cervix uteri in New South Wales, 1973–82. *Aust NZ J Obstet Gynaecol* 1989, **29**, 335–339.
10. McCredie M, Stewart JH, Mathew TH, Disney APS, Ford JM. The effect of withdrawal of phenacetin-containing analgesics on the incidence of kidney and urothelial cancer and renal failure. *Clin Nephrol* 1989, **31**, 35–39.
11. McCredie M, Coates MS, Churches T. *Cancer of the Cervix Uteri in New South Wales and the Australian Capital Territory*, 1972–1987 Sydney, NSW Cancer Council, 1990.
12. McCredie M, Coates MS, Ford JM. Epidemiology of cancers of the alimentary tract in New South Wales, 1973–82. *Aust NZ J Surg* 1990, **60**, 93–98.
13. McCredie M, Coates MS, Ford JM, Disney A, Auld JJ, Stewart JH. Geographical distribution of cancer of the kidney and urinary tract and analgesic nephropathy in Australia and New Zealand. *Aust NZ J Med* 1990, **20**, 684–688.
14. McCredie M, Coates MS, Ford JM. The changing incidence of cancer in adults in New South Wales. *Int J Cancer* 1988, **42**, 667–671.
15. McCredie M, Coates MS. *Cancer Incidence in Migrants to New South Wales, 1972 to 1984*. Sydney, NSW Cancer Council, 1989.
16. McCredie M, Coates MS, Ford JM. Cancer incidence in New Zealand-born residents of New South Wales. *NZ Med J* 1990, **103**, 61–63.
17. McCredie M, Coates MS, Ford JM. Cancer incidence in European migrants to New South Wales. *Ann Oncol* 1990, **1**, 219–225.
18. McCredie M, Coates MS, Ford JM. Cancer incidence in migrants to New South Wales. *Int J Cancer* 1990, **46**, 228–232.
19. McCredie M, Coates MS, Ford JM. Cancer incidence in migrants to New South Wales from England, Wales, Scotland and Ireland. *Br J Cancer* 1990, **62**, 992–995.
20. McCredie M, Coates MS. *Cancer Incidence by Region, New South Wales and the Australian Capital Territory, 1979 to 1983*. Sydney, NSW Cancer Council, 1990.
21. McCredie M, Ford JM, Taylor JS, Stewart JH. Analgesics and cancer of the renal pelvis in New South Wales. *Cancer* 1982, **49**, 2617–2625.
22. McCredie M, Stewart JH, Ford JM, MacLennan RA. Phenacetin-containing analgesics and cancer of the bladder and renal pelvis in women. *Br J Urol* 1983, **55**, 220–224.
23. McCredie M, Stewart JH, Ford JM. Analgesics and tobacco as risk factors for cancer of the ureter and renal pelvis in men. *J Urol* 1983, **130**, 28–30.
24. McCredie M, Stewart JH, Carter JJ, Turner J, Mahony JF. Phenacetin and papillary necrosis: independent risk factors for renal pelvic cancer. *Kidney Int* 1986, **30**, 81–84.
25. McCredie M, Stewart JH. Does paracetamol cause renal papillary necrosis or urothelial cancer? *Nephron* 1988, **49**, 296–300.
26. McCredie M, Ford JM, Stewart JH. Risk factors for cancer of the renal parenchyma. *Int J Cancer* 1988, **42**, 13–16.
27. World Health Organisation. International Classification of Diseases. Manual of the International Statistical Classification of Diseases, Injuries, and Causes of Death. WHO, Geneva, 1977.
28. Australian Bureau of Statistics. *Estimated Resident Population by Sex and Age: States and Territories of Australia*. Catalogue 3201.0. Canberra, ABS, 1982 and 1983.
29. Doll R. Comparison between registries. Age-standardized rates. Waterhouse J, Muir C, Correa P *et al.* eds *Cancer Incidence in Five Continents* Vol III. IARC Scientific Publication no 18, Lyon, IARC 1976, 453–459.
30. Holman CDJ, Hatton WM, Armstrng BK, English DR. *Cancer Mortality Trends in Australia. Vol II, 1910–1984*. Health Department of Western Australia, Perth, 1987.
31. Waterhouse J, Muir C, Shanmugaratnam K, Powell J, eds. *Cancer Incidence in Five Continents* Vol IV. IARC Scientific Publication no. 42, Lyon, IARC 1982.
32. Muir C, Waterhouse J, Mack T, Powell J, Whelan S. eds. *Cancer Incidence in Five Continents* Vol V. IARC Scientific Publication no. 88, Lyon, IARC 1987.
33. Holman CDJ, Armstrong BK, Arias LN, *et al. The Quantification of Drug Caused Morbidity and Mortality in Australia*. Commonwealth Department of Community Services and Health, Canberra, 1988.
34. Stewart JH. Analgesic abuse and renal failure in Australasia. *Kidney Int* 1978, **13**, 72–78.

Acknowledgements—Dr Joyce Ford was Registrar of the NSW Central Cancer Registry from 1971 to 1989.