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Malignant Mesothelioma in Australia, 1945–2000

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Australia has maintained a national malignant mesothelioma register since 1980. The register includes all cases in Australia. Currently 450–600 cases are notified annually in a population of 20 million. Australia has had 6329 cases of mesothelioma in the period 1 January 1945–31 December 2000. A further 680 cases have been notified in the period 1 January 2001–31 December 2001. Annual incidence rates for Australia per million population ≥20 yr (1998) were male, 59.8; female, 10.9; total, 35.4. Incidence rates have been continually increasing in males and females and are the highest reported national rates in the world. While Western Australia has the highest rate (1998, 52.8), most cases arise from the two most populous eastern states, New South Wales and Victoria. In 88% (male 90%, female 61%) of cases a history of asbestos exposure was obtained. Exposures occurred in a wide variety of occupational and environmental circumstances. In 81% of cases with no history of exposure, TEM lung asbestos fibre counts >200000 fibres >2 μm length/g dry lung were obtained, suggesting unrecognized exposure. Australia's high incidence of mesothelioma is related to high past asbestos use, of all fibre types, in a wide variety of occupational and environmental settings. The number of cases in total is expected to be about 18000 by 2020, with about 11000 yet to appear.

Keywords: malignant mesothelioma; incidence; Australia; asbestos exposure; future predictions

INTRODUCTION

Asbestos was mined in Australia for over one hundred years and Australia was the world's highest user per capita of asbestos in the 1950s. Given the ecological relationship between per capita asbestos consumption and mesothelioma incidence (Takahashi *et al.*, 1999), it is no surprise that in the last 20 yr of the 20th century Australia has had the world's highest reported incidence of malignant mesothelioma. Australia has one of the world's most complete national surveillance systems for mesothelioma and this has been in operation since 1980. It is the purpose of this paper to describe the history of asbestos use and the incidence of mesothelioma in Australia as a whole, rather than concentrating on the well-known Wittenoom crocidolite mining operation and township in Western Australia (Musk *et al.*, 1992). The paper updates and enhances previous reports (Leigh *et al.*, 1991, 1997, 1998; Leigh, 1994).

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MATERIALS AND METHODS

Australian Mesothelioma Surveillance Program (Ferguson et al., 1987)

The Program began on 1 January 1980 after preliminary work from 1977. Formal voluntary notification of cases was actively sought from a network of respiratory physicians, pathologists, general and thoracic surgeons, medical superintendants, medical records administrators, state and territory departments of occupational health, cancer registries, compensation authorities or any other source. Notifications from other than the diagnosing physician were confirmed with him/her. After gaining the appropriate consents a full occupational and environmental history was obtained for each case, either from the patient or next of kin. The history taking was non-directive but included specific questions on asbestos exposure at the end. These histories were coded by two occupational hygienists, who naturally could not be blinded to case status. They also discussed cases together and

were thus not independent. The diagnosing pathologist was requested to provide slides and or tissue specimens. These were circulated among a pathology panel for confirmation of diagnosis. Post-mortem examination was actively sought for in every case in order to confirm diagnosis and to obtain lung tissue free of tumour for lung fibre content analysis.

Australian Mesothelioma Register

From 1 January 1986, a less detailed notification system has operated, with a short questionnaire on occupational and environmental exposure history, which is followed up assiduously; there is no pathology panel diagnosis and only sporadic lung fibre counts. In the case of New South Wales and Western Australia (60% of all Australian notifications), histories are obtained from direct detailed questioning by compensation authorities or cancer registries. Only histologically confirmed cases are accepted and full reconciliation with all state cancer registries and compensation authorities is carried out. This is now known as the Australian Mesothelioma Register but is a continuation of the Program.

Incidence rates are periodically calculated on cases notified to the Register. An annual report series is produced (NOHSC, 1989–2001). Incidence rates have been calculated up to the end of 1998 only, because of the up to 2 yr delay in notification experienced while awaiting confirmed diagnosis and reconciliation with the state cancer registries.

RESULTS

The incidence of mesothelioma in Australia

From 1 January 1980 to 31 December 2000, a total of 5671 notifications had been received by the Program and Register. Between 1945 and 1979 there were 658 cases (535 male, 123 female) in Australia (Musk *et al.*, 1989). Thus the total number of mesotheliomas in Australia from 1945 to 2000 inclusive was 6329. A further 680 cases have been notified in the period 1 January–31 December 2001. Notifications show a continuing upward trend in both males and females (Fig. 1). The notifications prior to 1982 were probably the result of bedding in of a new Program and are artificially low (1980, 16; 1981, 104), although a smooth curve of increasing incidence starting from the early 1960s has since been demonstrated by a retrospective search (Fig. 2). The Australian population increased from 14.5 million in 1980 to 20 million in 2001. Mesothelioma incidence rates have increased from 12.8 per million population ≥20 yr age/yr in 1982 to 35.4 per million/yr in 1998 (males and females combined), 50.6 per million/yr (males) and 9.0 per million/yr (female). Figure 3 shows rates by time and sex. If the 1981 figure is accepted it can be claimed that mesothelioma incidence rates have increased 4- to 5-fold in 19 yr in Australia. Both male and female rates have increased but the male rate is over five times the female rate. These are the highest reported incidence rates in the world (Hillerdal, 1999; Peto *et al.*, 1999; Takahashi *et al.*, 1999; Kjellstrom and Smartt, 2000) and equal to the Australian (NSW) incidence rate of liver cancer, and in mortality terms equal to the mortality rates of kidney cancer in males and uterine cancer in females (NSW Cancer Council, 2000). Mesothelioma is no longer a 'rare disease'.

Table 1 shows notifications by state up to 31 December 2000.

Western Australia has the highest incidence (1998 rates: total 52.8, male 96.2, female 9.4) but contrib-

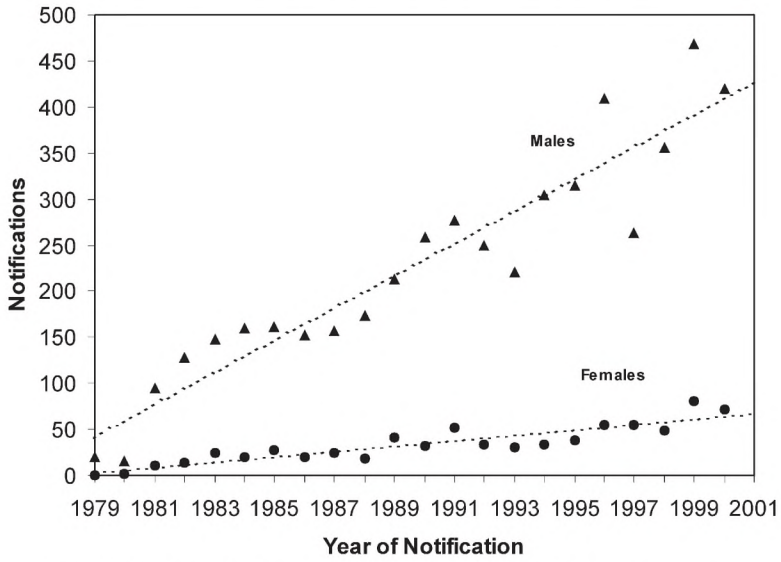

Fig. 1. Australian Mesothelioma Register notifications, 1979–2000 (by sex).

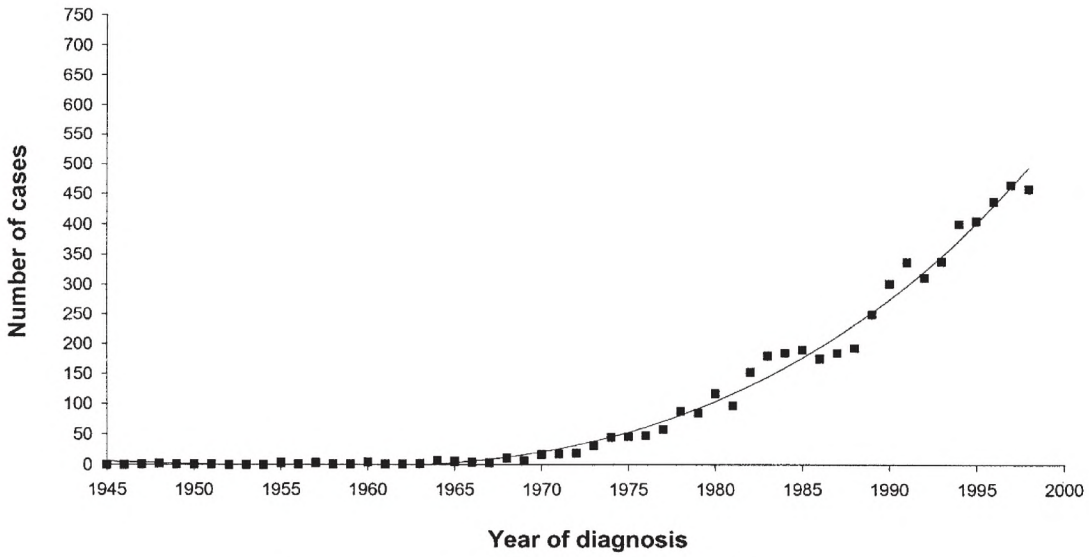

Fig. 2. Incident cases of mesothelioma in Australia, 1945–1998.

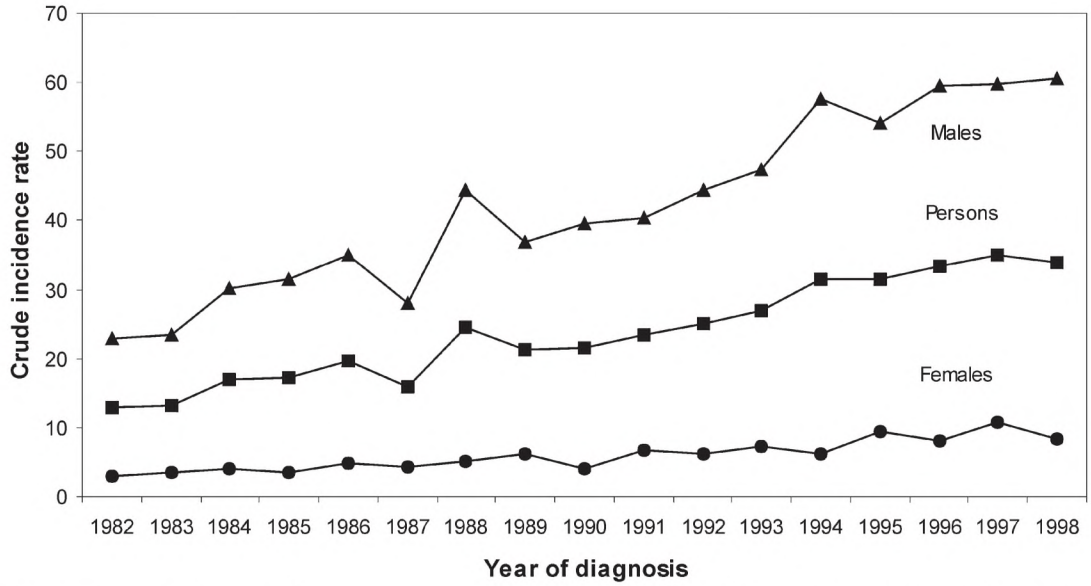

Fig. 3. Time trend of annual incidence rate (per million population ≥20 yr) of mesothelioma in Australia by sex, 1982–1998.

utes only 15% of the total cases. Wittenoom contributes only 5% of the Australian cases yet is certainly the most publicized and best known internationally. Most of the cases come from the two most populous and industrialized states, New South Wales and Victoria.

In 93.2% of all Program cases the mesothelioma was pleural in site, 6.5% peritoneal and only 0.3% of cases in other sites. Among men 94.3% were pleural, 5.3% peritoneal; among women 86.3% were pleural, 13.7% peritoneal. These proportions have been generally maintained in Register cases although the female peritoneal proportion has dropped to 10.4%.

The most common occupational exposures were repair and maintenance of asbestos materials (18%), shipbuilding (11%), asbestos cement production (7%), asbestos cement use (7%), railways (6%), Wittenoom crocidolite mining/milling (6%), insulation manufacture/installation (4%), wharf labouring (3%), power stations (3%), boilermaking (2%), para-occupational hobby and environmental (15%). When the earlier cases classed as 'no history of exposure' were reviewed it was found that 57 of the 203 so classified actually had a history of some exposure recorded. Thus only 19% had no known history. Moreover, of this 'no known history' group, 81% had

Table 1. Mesothelioma notifications in Australia, 1980–2000

	NSW	VIC	QLD	WA	SA	TAS	NT	ACT	Totals
1980	15	1	0	0	0	0	0	0	16
1981	51	3	18	22	5	5	0	0	104
1982	90	20	9	0	20	2	0	1	142
1983	53	23	26	46	19	6	0	0	173
1984	76	38	20	26	14	1	1	2	178
1985	71	39	27	30	19	1	0	2	189
1986	46	34	38	32	18	2	1	1	172
1987	54	40	26	28	32	0	0	2	182
1988	57	28	45	23	36	1	0	2	192
1989	124	25	35	44	22	3	0	1	254
1990	111	82	43	26	25	1	0	1	289
1991	105	44	46	66	55	10	0	2	328
1992	117	45	40	37	39	3	1	1	283
1993	99	34	42	47	25	5	0	0	252
1994	151	41	74	32	30	8	0	1	337
1995	124	89	49	33	43	11	1	3	353
1996	87	157	53	127	30	4	1	4	463
1997	107	32	64	82	24	5	0	4	318
1998	160	84	65	66	21	8	0	1	405
1999	252	113	73	79	20	7	0	7	551
2000	168	106	99	47	60	7	0	3	490
All	2118	1078	892	893	557	90	5	38	5671
%	37.3	19.0	15.7	15.7	9.8	1.6	0.1	0.7	100

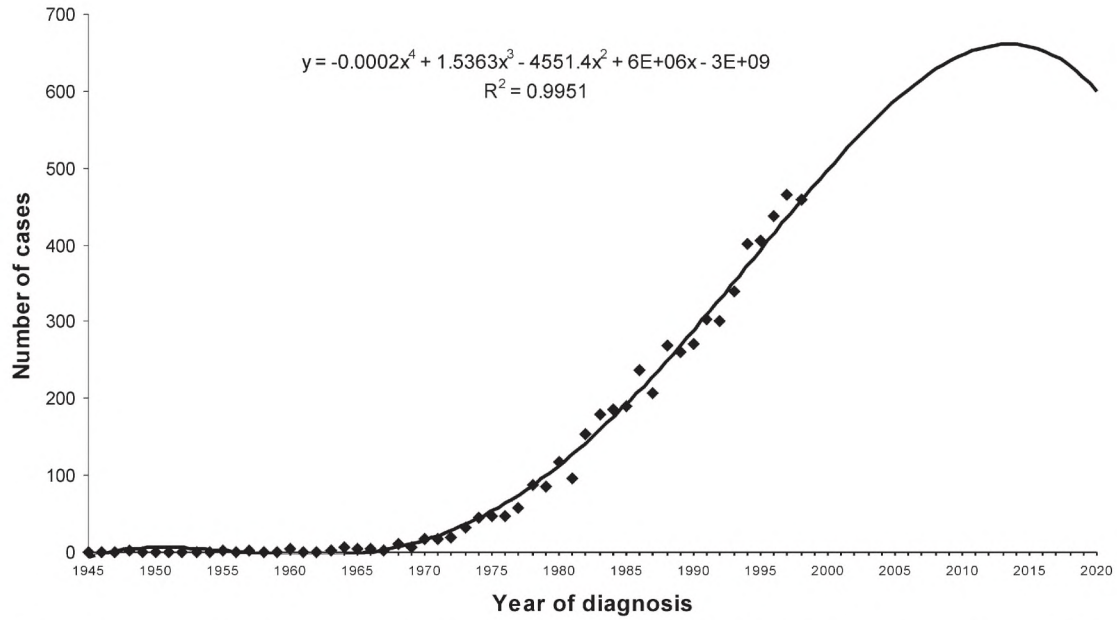

Fig. 4. Incident cases of malignant mesothelioma in Australia 1945–98 and extrapolation to 2020 assuming maximum at 2010.

fibre counts >200000 fibres/g dry lung detected in the lungs, 30% with more than 10^6 fibres/g >2 μm including 'long' (>10 μm) fibres, suggesting that nearly all cases had been exposed. Past exposure is not always recognized as such and this is more likely to be the case in females. Indeed even absence of fibres in the lungs does not negate exposure as fibres may have initiated mesothelioma and then been cleared before death. The shortest duration of exposure was 16 h (waterside worker loading crocidolite fibre (Musk

et al., 1991). Three percent of cases had exposures of less than 3 months. According to history assessment of the first exposure of the first 530 cases by the two hygienists, most cases (55%) had mixed amphibole–chrysotile exposure, 13% amphibole only, 7% amphibole, plus possible chrysotile, 6% chrysotile, with possible amphibole, and 4% chrysotile only, with 15% unknown fibre type (Grimwood, 1988). Mean latency from first exposure to presumptive diagnosis was 37.4 yr (Ferguson *et al.*, 1987). The range of latencies was 4–75 yr.

In the cases reported since 1 January 1986, when less detail of history of exposure was sought, 89.9% of males responding to the questionnaire and 61.2% of females gave a history of asbestos exposure (overall 86.4%) (non-response 22% males, 30% females). The pattern of exposure history is changing, and more product, domestic, environmental and para-occupational exposure is apparent, compared to the older traditional industries. Exposure occurred in a wide range of occupations and industries and non-occupational settings. Some common exposure histories were: repair and maintenance of asbestos materials (13%), shipbuilding (3%), asbestos cement production (4%), railways (3%), powerstations (3%), boilermaking (3%), Wittenoom (5%), wharf labour (2%), para-occupational, hobby, environmental (4%), carpenter (4%), builder (6%), navy (3%), plumber (2%), brake linings (2%), multiple (12%).

Risk in particular occupational groups

Approximate lifetime risks in occupational groups exposed 30–50 yr ago were obtained as follows:

$$\text{Lifetime risk (\%)} = (70 \times \text{number of mesothelioma cases notified 1986–2000} \times 100)/(\text{population in occupation category in Australia} \times 15)$$

Table 2 shows the results for the major identifiable occupational groups.

Population denominator data was estimated from census data, Australian Bureau of Statistics (ABS) data, cohort data for Wittenoom, defence data for the navy and union data for waterside workers. As the range of latencies was 4–75 yr, the relevant occupational group population sizes were estimated as the mean of the 1933 and 1997 value, except for Wittenoom, navy and waterside workers, where industry, defence and union data was used.

Table 2. Mesothelioma risks in occupational groups

Occupation	Lifetime risk of mesothelioma (%)
Wittenoom mine or mill worker	16.6
Power station worker	11.8
Railway labourer	6.4
Navy/merchant navy	5.1
Wittenoom town	3.1
Carpenter/joiner	2.4
Waterside worker	2.1
Plasterer	2.0
Boilermaker/welder	1.9
Bricklayer	1.8
Plumber	1.7
Painter/decorator	1.2
Electrical fitter, mechanic, electrician	0.7
Vehicle mechanic	0.7
All Australian men	*0.39*
All Australian women	*0.07*

CONCLUSION

The high and increasing incidence of mesothelioma in Australia is due to high asbestos use in the past, combined with poor hygiene practice, relatively high amphibole use in asbestos cement products, slow recognition of chrysotile mesotheliomagenicity and excessive focus on Wittenoom to the exclusion of other more common exposures. There was also a reluctance to recognize the causal significance of low occupational and non-occupational exposures.

The expected total number of mesothelioma cases in Australia from 1945 to 2020 is estimated to be about 18000, based on models by Berry (1991) and de Klerk *et al.* (1989) for Wittenoom, extrapolated to Australia as whole (assuming Wittenoom contributes 5% of cases), and direct extrapolation from the best fit to the empirical incidence curve, constrained to have a maximum value at 2010, following a 40 yr latency from the time of maximum exposure (1970) (Fig. 4). This will create a heavy clinical and compensation load. Cases will arise from a large variety of occupations and workforces and environmental and para-occupational circumstances. Although classic cohorts related to insulation work and crocidolite mining will have the highest risks, occupations such as carpenters, builders, plumbers and electricians, because of numbers employed, will generate similar case loads.

With asbestos-related lung cancer estimated to occur at a ratio of 2:1 to mesothelioma (Barroetavena *et al.*, 1996) the expected future case load of asbestos-related cancer can be expected to be of the order of 30 000–40 000 by 2020. These predictions are consistent on a population and asbestos use adjusted basis with those made for Europe (Peto *et al.*, 1999), Scandinavia, USA, Japan (Takahashi *et al.*, 1999) and New Zealand (Kjellstrom and Smartt, 2000).

The various Australian state and federal government preventive, clinical and compensatory authorities are now developing a national strategy for dealing with this problem.

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