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From: Dr. J. Leigh

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Malignant mesothelioma in Australia, 1945 to 2000

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Australia has maintained a total national malignant mesothelioma case register since 1980. There has been a marked increase in the incidence of mesothelioma in the last 20 years. Currently, 450 to 600 cases are notified annually in a population of 19 million. While the history of the Wittenoom (Western Australia) crocidolite mine and its aftermath are well known, Wittenoom cases comprise only 5% of the total Australian cases. This article describes the incidence of mesothelioma in Australia as a whole from 1945 to 2000.

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 18,000 by 2020, with about 11,000 yet to appear. These predictions are consistent on a population and asbestos use adjusted basis with those made for Europe, Scandinavia, the US and Japan.

KEYWORDS

- MALIGNANT MESOTHELIOMA
- INCIDENCE
- ASBESTOS EXPOSURE
- FUTURE PREDICTIONS

Method

Australian Mesothelioma Surveillance Program

The Australian Mesothelioma Surveillance Program (the Program) began on 1 January 1980 (after preliminary work from 1977).[18] Formal voluntary notification of cases was actively sought from a network of respiratory physicians, pathologists, general and thoracic surgeons, medical superintendents, medical records administrators, State and Territory departments of occupational health, cancer registries, compensation authorities and 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 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. Although the system includes a short questionnaire on occupational and environmental exposure history, it is followed up very assiduously (up to four letters per case); there is no pathology panel diagnosis and only sporadic lung fibre counts. In the case of NSW and WA (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 system is a continuation of the Program but it is now known as the Australian Mesothelioma Register (the Register). A copy of the current Register notification form is shown as Figure 2.

Incidence rates are periodically calculated on cases notified to the Register and an annual report series is produced.[19] Age standardised rates are based on the World Standard Population greater than 20 years.[20] Incidence rates have been calculated to the end of 1997 only because of the up to two-year delay in notification that is experienced while awaiting confirmed diagnosis and reconciliation with the State cancer registries. Rates to the end of 1998 are available in the *Australian Mesothelioma Register Report 2001*.[19]

Results

The incidence of mesothelioma in Australia

From 1 January 1980 to 31 December 2000, a total of 5,671 notifications had been received by the Program and Register. Between 1945 and 1979, there were 658 cases (535 male, 123 female) in Australia.[21] Thus, the total number of mesotheliomas in Australia from 1945 to 2000 inclusive is 6,329. (A further 600 cases have been notified in the period 1 January 2001 to 30 September 2001, some being incident in earlier years.) Notifications show a continuing upward trend in both males and females (Figure 3).

The notifications prior to 1982 were probably the result of bedding in the 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 (Figure 4).

The Australian population has increased from 14.5 million in 1980 to 19 million in 2000. Mesothelioma incidence rates, standardised to the World Population greater than 20 years, have increased from 11.8 per million per year in 1982 to 29.8 per million per year in 1997 (males and females combined) (or, 50.6 per

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FIGURE 2
Australian Mesothelioma Register Notification Form



NATIONAL OCCUPATIONAL HEALTH AND SAFETY COMMISSION
AUSTRALIAN MESOTHELIOMA REGISTER NOTIFICATION

Please direct all correspondence to:

The Registrar
Australian Mesothelioma Register
National Occupational Health and Safety Commission
GPO Box 58 Sydney NSW 2001
Telephone: (02) 9577 9304

Patient details - please supply ALL available information

SURNAME: ..... FIRST NAMES: .....

ADDRESS: .....

STATE: ..... POSTCODE: ..... GENDER: M / F DATE OF BIRTH: / /

IF DECEASED, DATE OF DEATH: / / PLACE OF DEATH: .....

DATE OF INITIAL DIAGNOSIS: Month ..... Year: ..... HISTOLOGICAL: YES / NO

HOSPITAL DIAGNOSED: ..... PRIMARY SITE: .....

CLINICIAN'S NAME: ..... NAME OF LOCAL GP: .....

ADDRESS: ..... ADDRESS: .....

.....

Please describe briefly main occupation(s) of patient's worklife.

OCCUPATION	INDUSTRY	YEAR
1.	1.	19 - 19
2.	2.	19 - 19
3.	3.	19 - 19

KNOWN ASBESTOS EXPOSURE: YES / NO

If "YES" please indicate circumstances and duration: .....

.....

.....

Details of person completing this form

NAME: ..... SIGNATURE: .....

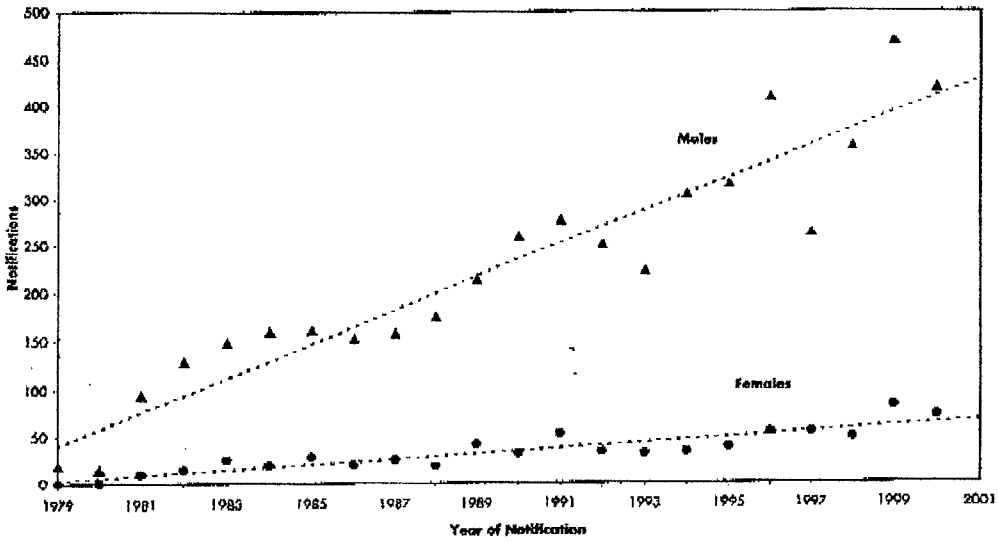
ADDRESS: ..... DATE: .....

Please circle the appropriate category: CLINICIAN PATHOLOGIST CANCER REGISTRY MEDICAL RECORDS ADMIN
DUST DISEASES BOARD OTHER: .....

Office Use Only
Date Received: REGISTRATION NO: | | | | | |

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FIGURE 3
Australian Mesothelioma Register notifications, 1979 to 2000 (by sex)



million per year (males) and 9.0 per million per year (females)). Corresponding crude rates for 1997 were 59.8 per million per year (males) and 10.9 per million per year (females). Figures 5 and 6 show crude and standardised rates by time and sex. If the 1981 figure is accepted, it can be claimed that mesothelioma incidence rates have increased four to five-fold in 19 years 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.[1,22-24] They are 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.[25] Mesothelioma is no longer a "rare disease".

Figure 7 shows age-specific incidence rates for males and females over 20 years of age for 1997. Incidence increases with age up to 80 years and then falls, consistent with a cohort effect in that the oldest persons may have missed the heaviest exposure era from 1950 to 1970. The occurrence of cases in the under 40-year age groups indicates that exposure can occur in children. Figures 8 and 9 show age-specific incidence trends over time for males and females. Generally, the time trend of increasing incidence is restricted to age groups over 50 years from 1986 onwards, suggesting that occupational exposure controls introduced from the 1970s have been effective. Figure 10 shows time trends in World Population > 20 years standardised mesothelioma incidence by State for recent years. Table 1 shows notifications by State up to 31 December 2000.

Western Australia has the highest incidence (1997 crude rates: total 52.8, male 96.2, female 9.4) but contributes only 15% of the total cases. Wittenoom contributes only 5% of the Australian cases, yet is

FIGURE 4
Incident cases of mesothelioma in Australia, 1945 to 1997

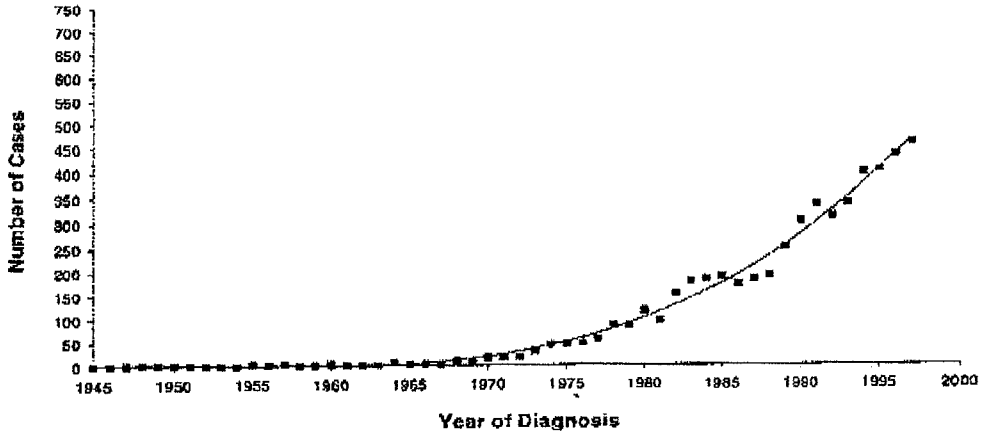
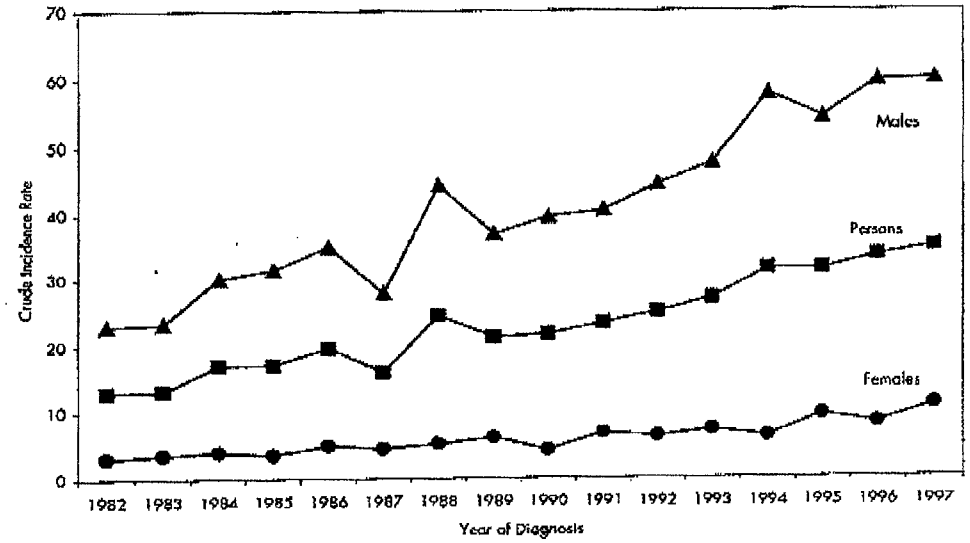


FIGURE 5
Time trend of crude annual incidence rate (per million population ≥ 20 years) of mesothelioma in Australia by sex, 1982 to 1997



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FIGURE 6
Time trend of age standardised annual incidence rate (per million population ≥ 20 years) of mesothelioma in Australia by sex, 1982 to 1997 (standardised to World Population)

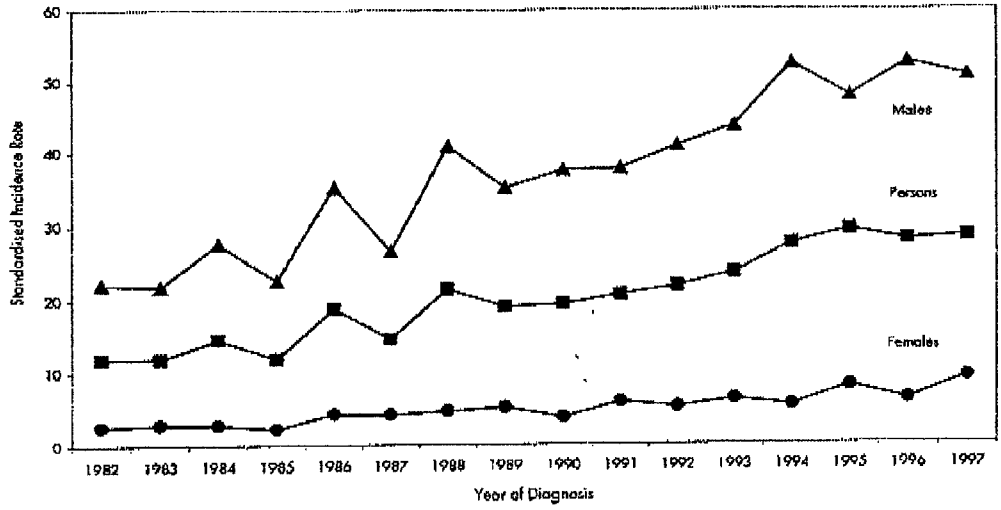


FIGURE 7
Age-specific incidence rates of mesothelioma in Australia, 1997 (male and female)

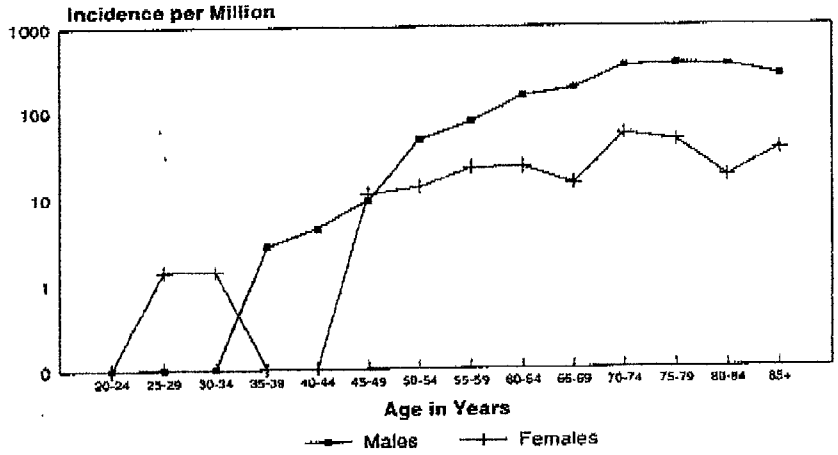


FIGURE 8
Age-specific incidence of mesothelioma in Australia, 1986 to 1997 (male)

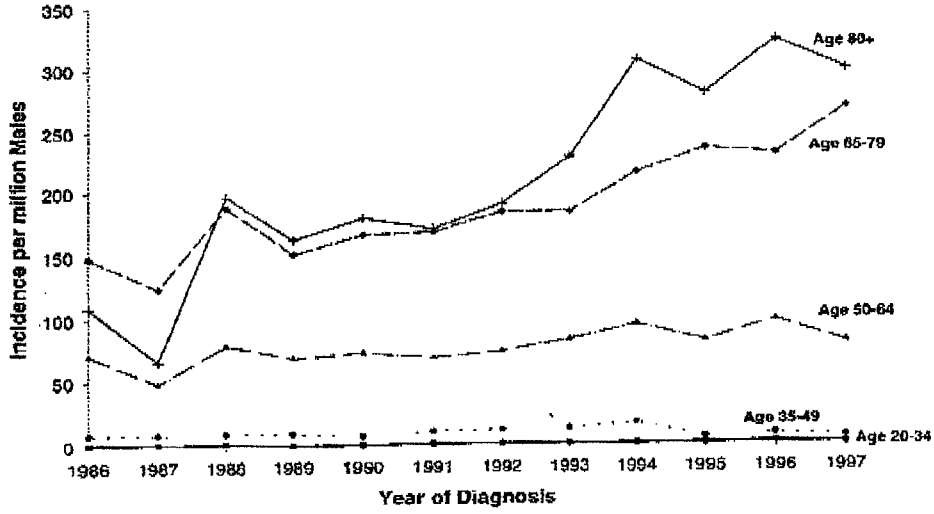
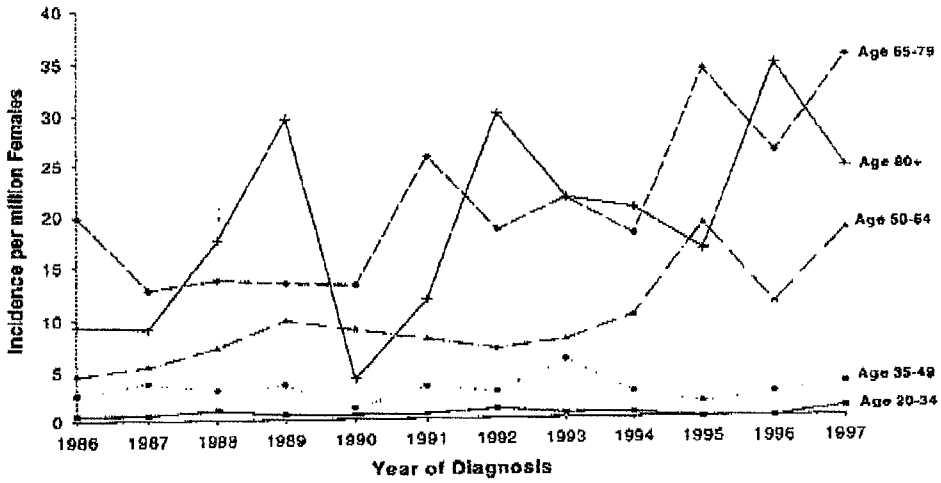
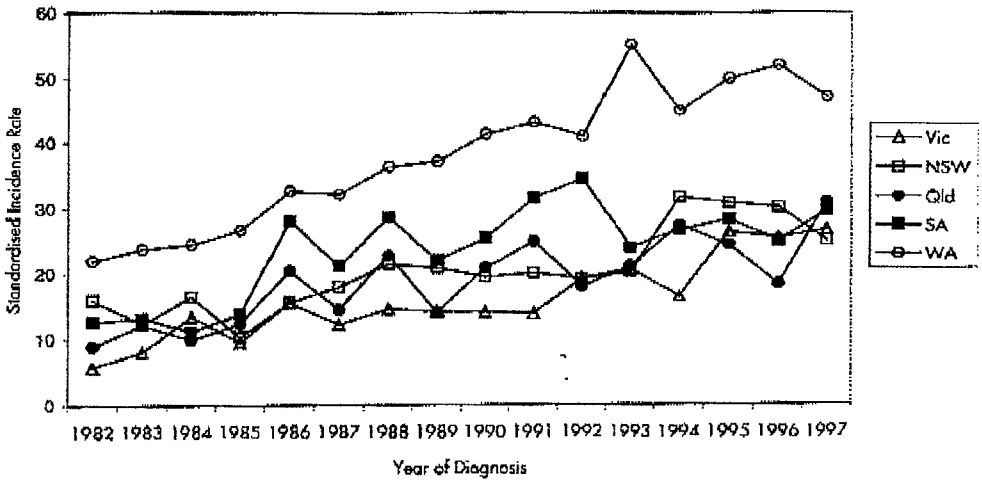


FIGURE 9
Age-specific incidence of mesothelioma in Australia, 1986 to 1997 (female)



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FIGURE 10
Time trend of age standardised annual incidence rate (per million population ≥ 20 years) of mesothelioma in Australia by State, 1982 to 1997 (standardised to World Population)



certainly the most publicised and best known internationally. Most of the cases come from the two most populous and industrialised States, that is, NSW and Victoria.

In 93.2% of all Program cases the mesothelioma was pleural in site, 6.5% of cases were peritoneal and only 0.3% were 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%. Of the cases that underwent pathology panel review, 96% were confirmed as mesothelioma (73% definite, 17% probable and 6% possible). 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%); and para occupational, hobby and environmental (15%). When the earlier cases classed as "no history of exposure" were reviewed, it was found that 37 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 transmission electron microscopy fibre counts > 200,000 fibres/gm dry lung detected in the lungs, 30% with more than 10^6 fibres/g > 2 micron including "long" (> 10 micron) fibres — suggesting that nearly all cases had been exposed. Past exposure is not always recognised 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 hours (a waterside worker loading crocidolite fibre).[3] Three per cent of cases had exposure of less than three months. According to history assessment by the two hygienists of the first exposure of 530 cases, most cases

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TABLE 1

Mesothelioma notifications in Australia, 1980 to 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	2,118	1,078	892	893	557	90	5	38	5,671
%	37.3	19.0	15.7	15.7	9.8	1.6	0.1	0.7	100

(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).[17] Mean latency from first exposure to presumptive diagnosis was 37.4 years.[18] The range of latencies was 4 to 75 years.

In the cases reported since 1 January 1986, when less detail of history of exposure was sought, 89.9% of males responding to questionnaires 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 with the older traditional industries. Table 2 shows the circumstances of exposure in cases from 1986 to 2000. This is a combination of occupation and industry or domestic or environmental circumstance. 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%); power stations (3%); boilermaking (3%); Wittenoom (5%); wharf labour (2%); para occupational, hobby and environmental (4%); carpenter (4%); builder (6%); navy (3%); plumber (2%); brake linings (2%); and multiple (12%).

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TABLE 2

Asbestos exposures as documented in the Australian Mesothelioma Register from 1 January 1986 to 31 October 2000

Circumstances of exposure	*Number exposed (with no other exposure) (single)*	*Number exposed (with other exposures) (multiple)*	*Total exposures*
Acoustic engineer	1	–	1
Airconditioning	12	14	26
Aircraft	11	3	14
Armed forces/wartime	28	16	44
Armed forces/peacetime	6	2	8
Asbestos bagging (not Wittenoom)	8	4	12
Asbestos bags: handled which had contained	8	–	8
Asbestos clothing worn	9	4	13
Asbestos covers for cooking	3	–	3
Asbestos dwelling/fence: built/renovated	70	13	83
Asbestos dwelling: lived in	29	8	37
Asbestos products: lived near	11	2	13
Asbestos products factory: worked near	11	–	11
Asbestos mine: worked/lived near (not Wittenoom)	12	6	18
Asbestos product handled in the workplace	42	8	50
Asbestos product manufacturer: worked	106	36	142
Asbestos product part of workplace or surrounds	26	9	35
Asbestos tailings: played on as a child	8	4	12
Asbestos/or products worker; lived with/washed clothes	42	6	48
Bakery (ovens)	3	–	3
Boilermaker/cleaner/attendant/installer/welder	79	54	133
Brake linings: made/repaired	58	19	77
Brewery	1	–	1
Bricklayer	15	4	19
Brickworks	8	3	11
Builder/builder's labourer	185	40	225
Carpenter/joiner	224	42	266
Cement factory worker	20	1	21
Chemical engineer	1	–	1
Civil engineer	7	–	7
Concreting	5	3	8
Construction worker	12	2	14
Demolition	5	2	7
Design engineer	2	1	3
Diesel engineer	–	1	1
Dockyard worker	40	23	63
Electrical engineer	5	7	12
Electrical fitter	15	4	19

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Circumstances of exposure	Number exposed (with no other exposure) (single)	Number exposed (with other exposures) (multiple)	Total exposures
Electrical mechanic	3	—	3
Electrician	55	12	67
Electroplater	—	1	1
Engineer	26	1	27
Fireproofing	5	—	5
Firedoors	5	—	5
Firefighter	5	3	8
Fitter/turner	51	20	71
Foundry	6	2	8
Furnace	6	—	6
Glassworks/glaziers	6	—	6
Industrial chemist	4	—	4
Industrial engineer	2	—	2
Instrument technician	1	—	1
Insulation	18	4	22
Jeweller	6	2	8
Laboratory technician	6	2	8
Labourer	33	15	48
Lagger	31	16	47
Lagging in workplace	24	4	28
Laundry/dry cleaners	14	5	19
Linesman	9	4	13
Locksmith	1	—	1
Machine fitter	3	1	4
Machine inspector	2	—	2
Machine operator	1	3	4
Machinist	3	—	3
Maintenance carpenter	3	1	4
Maintenance electrician	2	1	3
Maintenance engineer	3	1	4
Maintenance fitter	13	4	17
Maintenance mechanic	3	2	5
Maintenance worker	12	3	15
Marine engineer	9	7	16
Mechanical engineer	5	—	5
Mechanical fitter	7	3	10
Metal fabrication	2	—	2
Metal trades	3	1	4
Metallurgy	1	—	1
Moulder	4	—	4
Navy/merchant navy	160	64	224

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Circumstances of exposure	Number exposed (with no other exposure) (single)	Number exposed (with other exposures) (multiple)	Total exposures
Oil refinery	7	2	9
Painter/decorator	37	8	45
Panel beater	9	1	10
Papermill	3	2	5
Patternmaker	6	3	9
Pipes: handled/cut/stored/drilled	24	5	29
Plasterer	16	7	23
Plumbing	56	27	83
Power station worker	86	51	137
Pre-pak maufacturer	1	—	1
Printing	10	—	10
Radiographer	2	—	2
Railways	101	49	150
Renovations/maintenance/lagging in workplace	21	5	26
Roofing	16	4	20
Sheetmetal	14	11	25
Ships: building/repairing/on	75	57	132
Shop fitter	1	—	1
Site visits/inspections	8	7	15
Smelting	1	—	1
Steelworks	13	8	21
Storeman	15	—	15
Stoves	2	—	2
Sugar mill	6	4	10
Tannery	2	—	2
Telephone technician	6	3	9
Tiler	11	1	12
Toolmaker	4	2	6
Trades assistant	17	3	20
Transporting asbestos	14	6	20
Transporting asbestos product	15	2	17
Tyre factory	10	4	14
Waterside worker	94	13	107
Weighing trucks	1	—	1
Welder	22	9	31
Whitewash: Greece/Cyprus	4	1	5
Wine making (filters)	1	—	1
Wittenoom (former mining area in WA)	193	51	244
Wood machinist	3	—	3

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Summary of asbestos exposures

Asbestos exposure:	
Single	2,608
Multiple	400
Possible	274
No apparent asbestos exposure	457
No response to questionnaire	1,099
Total cases from 1/1/86 to 31/10/2000	4,838
Proportion of respondents with asbestos exposure	3,282 / 3,739 = 88%

Risk in particular occupational groups

Approximate lifetime risks in occupational groups exposed 30 to 50 years ago were obtained as follows:

Lifetime risk (%) =

$$70 \times \frac{\text{number of mesothelioma cases notified 1986 to 2000} \times 100}{\text{Population in occupation category in Australia} \times 15}$$

For major identifiable occupational groups, the results are shown in Table 3.

Population denominator data were estimated from census data, Australian Bureau of Statistics labour force data, cohort data for Wittenoom, defence data for the navy, and union data for waterside workers. As the range of latencies was 4 to 75 years, the relevant occupational group population sizes were estimated as the mean of the 1933 and 1997 value, except for Wittenoom, navy and waterside workers.

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 recognise the causal significance of low occupational and non-occupational exposures and a tendency to ignore or discredit the warnings of scientists like the late Irving Selikoff.

It is now apparent that nearly all human mesothelioma cases result from asbestos or erionite exposure which may be of very small magnitude. Other proposed risk factors or co-factors, such as radiation and inflamatory lung conditions, are supported only by anecdotal evidence at best. Indeed, a recent large study of mesothelioma after radiotherapy for breast cancer in US nurses is convincingly negative.[36] The case for SV40 virus involvement as a co-factor is still unproven and subject to doubt. While there is a dose response relationship with asbestos exposure, the lower threshold has not been identified (although recent studies have shown it to be less than 0.15 fibre yr/ml).[37] If there is a "background incidence rate", it has been estimated to be much less than 1 per million per year.[38]

The relative mesotheliomagenicity of crocidolite, amosite and chrysotile is still uncertain but a common general consensus view is approximately crocidolite:amosite:chrysotile = 30:15:1.[39]

The expected total number of mesothelioma cases in Australia from 1945 to 2020 is estimated to be about 18,000, based on models by Berry and de Klerk et al for Wittenoom, extrapolated for Australia as a 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-year latency from the time of maximum exposure, that is, 1970 (Figure 11).[11,12] 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

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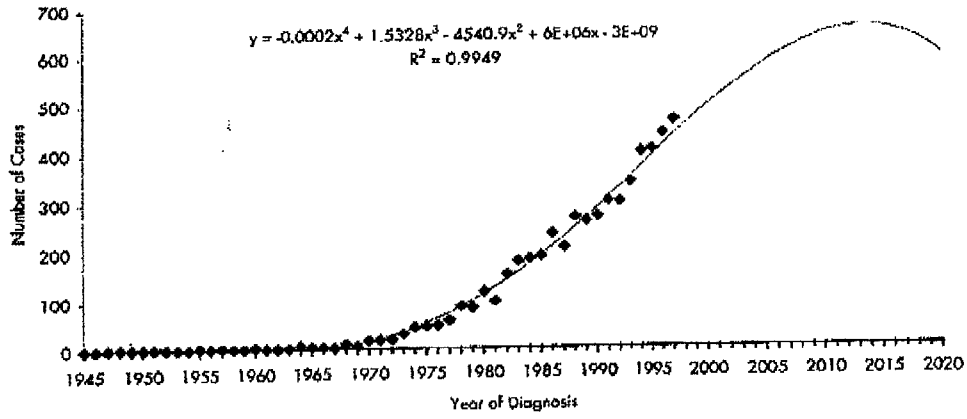
TABLE 3

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*

FIGURE 11

Incident cases of malignant mesothelioma in Australia, 1945 to 1997, and extrapolation to 2020 assuming maximum at 2010



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highest risks, occupations such as carpenters, builders, plumbers and electricians, because of the numbers employed, will generate similar case loads. The risk in brake mechanics is also elevated, consistent with chrysotile only causation.[30]

With asbestos-related lung cancer estimated to occur at a ratio of 2:1 to mesothelioma, the expected future case load of asbestos-related cancer can be expected to be of the order of 30,000 to 40,000 by 2020.[31] This prediction is consistent, on a population and asbestos consumption adjusted basis, with those made for Europe, the US and Japan.[32,33,35]

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