

# Incidence of malignant mesothelioma in Aboriginal people in Western Australia

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The Wittenoom Gorge in the Hamersley Ranges of the remote Pilbara region of Western Australia (WA) is about 1,600 kilometres north-east of Perth. The area is well known for the mining of asbestos in the past: blue asbestos (crocidolite) was mined and milled there by the Australian Blue Asbestos Company (ABA) between 1943 and 1966 (and earlier in nearby Yampire Gorge). Nearly 7,000 people, mostly men, worked at the mine and mill during this time. More than 300 of these former workers have died of malignant mesothelioma (MM) and many more have developed or died of other asbestos-related diseases (ARDs).<sup>1,2</sup> The Wittenoom mining operation has been classified as a “modern industrial disaster”<sup>3</sup>

The town of Wittenoom was about 12 km from the mill and was heavily contaminated with asbestos tailings, which were used extensively for dust suppression in backyards, driveways and roads, on the racetrack and in the school playground. Exposure to asbestos in the town has been responsible for many cases of MM and other ARDs among people who did not work for the asbestos company.<sup>4,5</sup> The township of Wittenoom was de-gazetted in 2006 and the areas around the mine and town-site were classified as contaminated sites, not suitable for any form of human occupation or land use.<sup>6</sup> Measurements and estimates of dustiness of the mine and mill and in the town during the period of operation of the industry and subsequently have revealed significant

## Abstract

**Objectives:** To describe the incidence of malignant mesothelioma (MM) in Aboriginal people in Western Australia (WA) and determine the main routes of exposure to asbestos in this population.

**Methods:** All MM cases in Western Australia, as well as the primary source of asbestos exposure, are recorded in the WA Mesothelioma Register. Aboriginal cases up to the end of 2013 were extracted from the register and compared with non-Aboriginal cases with respect to the primary means/source of exposure. Age-standardised incidence rates for each decade from 1980 were calculated for both Aboriginals and non-Aboriginals. Age-standardised mortality rates were calculated for the period 1994–2008 and compared with international rates.

**Results:** There were 39 cases (77% male) of MM among WA Aboriginal people. Twenty-six (67%) were a direct result of the mining of crocidolite at Wittenoom and the subsequent contamination of the surrounding lands. Of the non-Aboriginal MM cases (n = 2070, 86.3% male), fewer than 25% can be attributed to Wittenoom. Aboriginals had consistently higher 10-year incidence rates than non-Aboriginals and, when compared to world populations, the highest mortality rate internationally.

**Conclusion:** When incidence rates in Aboriginal people are compared with non-Aboriginal people, the Wittenoom mining operation has had a disproportionate effect on MM incidence in the local Aboriginal population.

**Key words:** Aboriginals, asbestos, malignant mesothelioma

ongoing contamination.<sup>7,8</sup> Furthermore, raw asbestos was transported more than 300 km from the mill by road to the nearest port, contaminating towns such as Roebourne – where the asbestos was temporarily stored – and Point Samson and Port Hedland, from where it was shipped to Perth.

The township of Wittenoom and associated mined and contaminated zones lie in traditional Banyjima (the local Aboriginal people) country and was inhabited by

these people for tens of thousands of years.<sup>9</sup> The Wittenoom and Yampire Gorges were significant cultural centres due to the permanent water supplies, availability of game and high number of cultural sites.<sup>9</sup> Despite the mining activity and subsequent contamination, the area around Wittenoom remains important to the Banyjima people, who continue to visit the gorge for swimming, fishing, cooking and cultural purposes.<sup>9</sup> Aboriginal people lived in and around the town of Wittenoom, while it

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existed, and although there were no official records of Aboriginal employment in the asbestos mining operations, it is well known that they did work in the mine and mill<sup>10,11</sup> as well as in the transport of raw asbestos from the mill to the coast.<sup>11,12</sup>

By 1995, there had been 12 cases of MM documented among WA Aboriginal people. All had lived or worked in the Pilbara region.<sup>13</sup> A crude incidence rate of 250 per million person-years was estimated, which was 5 to 10 times higher than any other population-based rate at the time. This was estimated using only the Pilbara Aboriginal population, which constitutes about 10% of the entire WA Aboriginal population, because all cases were considered to be from that area. The aim of the current study was to update the number of cases and the incidence rates of MM in the WA Aboriginal population and assess their main routes of exposure.

## Methods

### Cases

All cases of MM since the first case in 1960 are recorded in the WA Mesothelioma Register. Every case has been reviewed at regular meetings of the WA Mesothelioma Register Committee (WAMRC), whose members are an expert pathologist, an occupational physician, a respiratory physician, an epidemiologist, the Principal Medical Officer of the WA Cancer Registry and a research officer. The WA Mesothelioma Register entry for each case includes age, sex, date and methods of diagnosis, histological subtype, site of disease, date of death and available history of asbestos exposure. Aboriginality is also recorded. The written report of the diagnostic pathologist responsible for the cytological or histopathological diagnosis of each case is reviewed to confirm the diagnosis and, in difficult cases, the original diagnostic material is reviewed by the Register's expert pathologist, together with clinical and radiological information.

### Classification of exposure

The method of assessing the main source of asbestos exposure of this population has been previously reported.<sup>9</sup> Exposure information has been collected from a self-reported questionnaire (up to 1980), clinical notes, doctors' letters and advocacy groups. All available information is bought together in the WA Mesothelioma Register and each case is reviewed by the WAMRC

to classify the most significant source of asbestos exposure. There are 29 exposure classifications (22 occupational, five non-occupational, plus 'known no exposure' and 'unknown' exposures). Occupational categories include, among others, asbestos mining, asbestos transport, building and construction, plumbing and electrical work. The codes assigned are, in principle, independent of each person's 'main' lifetime occupation. Among the non-occupational exposure categories are former Wittenoom residents, visitors to Wittenoom and home renovators. 'Known no exposure' is coded if the person has been intensively questioned, but no source of exposure to asbestos can be identified. 'Unknown' exposure is coded if the person has not been adequately questioned, or there is insufficient detail in the exposure history. If there has been more than one source of asbestos exposure, the committee considers the most significant exposure for classification, taking account of when the exposure occurred, and the amount of exposure involved. For example, occupational exposure would usually be considered more significant than non-occupational exposure. Due to the potency of crocidolite for MM and the high exposures at both the Wittenoom mine and town site, exposure at Wittenoom – either as a former worker or ex-resident – is usually considered the most significant exposure.

### Statistical analyses

Differences between Aboriginal and non-Aboriginal cases for sex, age at diagnosis, age at first exposure to asbestos, MM site (right or left pleura, peritoneal, other), histological subtype and exposure categories were assessed using Mann-Whitney and Chi-square tests of statistical significance, as appropriate.

For internal comparisons, i.e. WA Aboriginal and non-Aboriginal cases, directly age-standardised incidence rates (ASIRs) were calculated. For MM, incidence and mortality rates are similar, as MM is a universally fatal disease with a short survival time. However, incidence rates were used as at any one time there will be more incident cases than deaths. Furthermore, there is more diagnostic certainty for incidence than mortality. Age-standardised IRs were calculated separately for Aboriginal and non-Aboriginal cases using the 2001 Australian population data.<sup>14</sup> Due to the small numbers for the Aboriginal population, ASIRs were calculated over 10-year periods, commencing in 1980 (there were only two Aboriginal

cases in the 1970s) up until 2013. Rates were calculated for all cases (males and females combined) and males only. Population data, for denominators, were obtained from the Epidemiology Branch of the WA Department of Health, where estimates of the sizes of the Aboriginal and non-Aboriginal populations, based on census data, were available from 1983 to 2011. Person-years (py) for the years 1980 to 1982 were based on the population in 1983. Person-years for 2012 and 2013 were based on the population in 2011.

International age-standardised mortality rates (ASMRs) for mesothelioma for the period between 1994 and 2008 have been published.<sup>15</sup> For comparison with these data, ASMRs for both Aboriginal and non-Aboriginal people, male and female combined, for the same period (1994–2008) were calculated. To be consistent with the published data<sup>15</sup> ASMRs were calculated using the 2000 World Standard population.<sup>16</sup>

## Results

Up to the end of 2013, there had been 2,124 registered MM cases in WA: 2,070 cases were non-Aboriginal, 39 cases were Aboriginal and racial status was unknown for 15 cases (Table 1). The first Aboriginal MM case was diagnosed in 1975. Of the 39 cases, 36 were pleural MM and three were peritoneal MM, which is a similar proportion to the non-Aboriginal group. There were also similar proportions of the various histological MM subtypes (epithelioid, sarcomatoid and biphasic) in Aboriginal and non-Aboriginal patients. There were relatively more MM cases for Aboriginal women than for non-Aboriginal women (23.0 v 13.7%), but this was not statistically significant ( $p=0.10$ ). Aboriginals were significantly younger than non-Aboriginals at diagnosis and at age of first exposure.

Twenty-six of the 39 Aboriginal MM cases could be directly related to the Wittenoom mining operations (five mine and mill workers, 12 transport workers, five Wittenoom residents and four Wittenoom visitors). A further three (with unknown exposure) resided in the Pilbara region at time of diagnosis. There were proportionally more MM cases from non-occupational exposures in Aboriginal people compared with non-Aboriginal people (28.0% v 13.9%,  $p=0.02$ ), see Table 2. Most (9/11; 81.8%) non-occupational exposures for Aboriginal people were a result of living in, or visiting

**Table 1: Description of Aboriginal and non-Aboriginal MM cases.**

	Aboriginal n=39	Non-Aboriginal n=2,070	p-value*
Sex (M/F)	30/9	1,786/284	0.091
Age (yrs) <sup>a</sup>			
Persons	57.9 (52.5–67.0)	69.0 (61.0–77.2)	<0.001
Male	58.0 (53.4–78.4)	69.1 (61.4–77.0)	<0.001
Female	55.6 (43.8–64.4)	68.8 (58.7–78.4)	0.007
Site (Pleural/Peritoneal)	36/3	1937/133	0.743
Histological subtype (n(%))			
Unspecified	1 (2.6)	134 (6.5)	0.302
Biphasic	8 (20.5)	271 (13.1)	
Epithelioid	25 (64.1)	1242 (60.0)	
Sarcomatoid	5 (12.8)	423 (20.3)	
Age at first exposure (yrs) <sup>a</sup>			
Persons	16.0 (10.0–22.0)	21.0 (16.0–29.0)	0.001
Male	17.5 (10.8–23.5)	21.0 (16.0–29.0)	0.017
Female	8.0 (2.5–17.0)	22.0 (13.8–30.3)	0.015
Survival time (days) <sup>a</sup>			
Persons	219 (62–452)	256 (114–516)	0.217
Male	219 (75–428)	250 (111–498)	0.216
Female	316 (57–604)	299 (125–600)	0.603

\* Chi-square test for proportions or Mann-Whitney test for continuous data  
a: Median (Interquartile range)

Wittenoom: for non-Aboriginal people ex-residents and visitors of Wittenoom accounted for 31.4% (90/287) of non-occupational cases. The proportion of cases attributed to working in the Wittenoom mine or mill was similar between the two groups, but there were proportionally more Aboriginal than non-Aboriginal MM cases associated with the transport of raw asbestos

fibres (30.7% and 4.7%, respectively). The most common occupational exposure for non-Aboriginal people was in building and construction (17.7%), but this only accounted for 7.7% of Aboriginal cases.

In most decades, Aboriginals had higher age-standardised incidence rates than non-Aboriginals (Table 3). When compared with international mortality rates for the period of 1994–2008,<sup>15</sup> WA Aboriginals had the highest rate, more than double the rate of the UK, which had the highest country-rate (Table 4).

**Table 2: Selected exposure categories for Aboriginal and non-Aboriginal MM cases.**

Exposure category	Aboriginal	Non-Aboriginal
<b>Non-occupational</b>	11 (28.0%)	287 (13.9%)
Wittenoom residents	5 (12.8%)	72 (3.5%)
Wittenoom visitors	4 (10.3%)	18 (0.9%)
<b>Occupational</b>	23 (59.0%)	1,488 (71.9%)
Wittenoom worker	5 (12.8%)	325 (15.7%)
Asbestos transport (road, rail and wharf)	12 (30.7%)	96 (4.7%)
Building and construction	3 (7.7%)	367 (17.7%)
<b>Unknown exposure</b>	5 (12.8%)	218 (10.5%)

### Discussion

There have been 39 recorded cases of MM in WA Aboriginal people since the mid-1970s and most were exposed to asbestos when living or working in and around Wittenoom, Roebourne and Port Samson. Incidence and mortality rates for MM in WA Aboriginal people are considerably higher than rates

in international populations. For most (67%) of the Aboriginal cases, asbestos exposure was due to the mining of crocidolite at Wittenoom, either working at the mine or as a result of contamination of the surrounding lands. As Aboriginal people still regularly visit the Wittenoom area, the risk of further exposure and future cases continues.

The age-standardised incidence rates for WA Aboriginal people tended to be higher than those of WA non-Aboriginal people when compared over 10-year periods but, due to the small number of Aboriginal cases, differences between the two groups have varied considerably over the decades. When compared with international data over an extended period of time, the MM mortality rate in WA Aboriginal people was considerably higher than all other populations. There is no known biological reason why Aboriginal people would be more susceptible to asbestos, although heterogeneity in risk of other cancers (such as lung) is recognised with different ethnicities.<sup>17</sup> The most likely reason for the higher incidence/mortality rates is that the predominant asbestos exposure for WA Aboriginals, both occupationally and non-occupationally, has been to crocidolite – the most potent asbestos fibre type for MM causation.<sup>18</sup> For Aboriginals, 74% and 82% of occupational and non-occupational cases, respectively, were associated with the Wittenoom mining operations, compared with 22% and 31%, respectively, for non-Aboriginal cases.

There are no official records of Aboriginal workers in the Wittenoom mining operations, but there is documented evidence that they did work there and were more likely to be given lower-paid jobs and jobs involving

**Table 4: WA Aboriginal and non-Aboriginal and International 15 age-standardised MM mortality rates (per 100,000) for the period 1994 to 2008.**

Population/country	Age-standardised mortality rate per 100,000 <sup>a</sup>
WA Aboriginal	4.11
WA non-Aboriginal	2.74
United Kingdom	1.78
Australia	1.65
Italy	1.03
France	0.76
Germany	0.68
South Africa	0.67
The Netherlands	0.64
USA	0.50

a: Period MR from 1994 to 2008, age-adjusted to the world population of 2000

**Table 3: Aboriginal and non-Aboriginal age-standardised MM incidence rates per 100,000 (number of cases) with 95% CI, for each decade from 1980 to 2013.**

Decades	Persons		Males only	
	Aboriginal	Non-Aboriginal	Aboriginal	Non-Aboriginal
1980–89	4.09 (6) 1.41–8.98	2.32 (256) 2.04–2.63	8.20 (6) 2.87–17.87	4.24 (222) 3.68–4.85
1990–99	3.66 (9) 1.65–7.12	3.92 (555) 3.60–4.26	6.83 (8) 2.88–13.83	7.67 (482) 7.00–8.39
2000–09	5.15 (14) 2.51–9.19	4.28 (815) 3.99–4.58	8.82 (10) 3.56–17.51	7.87 (688) 7.29–8.50
2010–13	6.16 (8) 2.24–13.08	4.24 (378) 3.82–4.69	8.42 (4) 1.44–23.97	7.82 (323) 6.99–8.73

dusty conditions.<sup>11,12,19</sup> One of the lowest paid jobs was the loading of crocidolite for transport from the mine to the nearby ports, either Point Samson or Port Hedland, which are more than 300 km from Wittenoom.<sup>11,12</sup> There was a considerably larger proportion of occupational exposures among Aboriginal cases due to transport and loading of raw asbestos, consistent with the anecdotal evidence.<sup>11,12</sup> Throughout the life of the Wittenoom operation, the asbestos was transported in bags made from jute fibre, even though their use had been prohibited for asbestos transport elsewhere as early as 1931 because of the levels of asbestos dust released.<sup>20</sup>

The high proportion of Aboriginal cases associated with the Wittenoom mining operations may also be due to under-representation of Aboriginal people in other asbestos-related occupations. For non-Aboriginal cases, occupational exposures other than mining, milling or transport of raw asbestos accounted for 57% of all cases, while only six (15%) of the Aboriginal cases had an occupational exposure category other than asbestos mining, milling or transport. Aboriginals have had, and continue to have, high levels of unemployment; often four to six times higher than the non-Aboriginal population.<sup>21</sup> Furthermore, up until the late 1960s – before Aboriginals were given citizenship rights – there were legislated restrictions on where Aboriginals could work, and they were largely employed during this time as indentured workers on the pastoral stations, in the pearling industry and in alluvial mining.<sup>10,22</sup>

On average, Aboriginal cases of MM have been diagnosed at a significantly younger age than non-Aboriginal cases. There are two reasons that may account for this. Firstly, the average reported age at first exposure was significantly lower for Aboriginal people, particularly for women (although this was based on information for five cases only). This observation probably reflects the increased proportion of non-occupational exposures in the Aboriginal group who lived in contaminated locations. Secondly, Aboriginal people have a shorter life expectancy than the non-Aboriginal Australian population and may therefore die of other causes before developing or being diagnosed with MM – life expectancy of Aboriginal people is about 11 years less than non-Aboriginal people due to circulatory, respiratory and metabolic diseases and neoplasms.<sup>23</sup> Because MM is

principally a disease of old age (by virtue of the latency and usual age of first exposure), the distributions of age at first exposure, age at diagnosis, and latency periods will be truncated at higher ages leading to lower averages than among the rest of the population.

It is possible that not all cases of MM in Aboriginal people have been recorded because of the remoteness of residence of many Aboriginal people and limited access to medical facilities. The under-use of health services by Aborigines is a contributing cause of the health disparity between Aboriginal and non-Aboriginal Australians.<sup>24</sup> Distance, cost and/or lack of culturally safe services are reasons why Aboriginal people may not use health services. Furthermore, there may be cases of MM in individuals, both Aboriginal and non-Aboriginal, who were exposed in WA but subsequently left the state and were diagnosed elsewhere. Due to the small number of Aboriginal cases, this would have a greater effect on Aboriginal than non-Aboriginal disease rates. It is possible, therefore, that the already high incidence and mortality rates for the WA Aboriginal population are under-estimated.

Calculating the incidence/mortality rates for the Aboriginal population may be inaccurate, as it is not known if Aboriginality is under- or over-reported in the census data.<sup>25</sup> The number of people identifying as Aboriginal in the four censuses between 1986 and 2001 rose at a rate far exceeding that of the total population, and far exceeding that expected from natural increase – most likely due to a general increased preparedness to identify as Indigenous.<sup>25</sup> Furthermore, census collection in remote Aboriginal Australia is a complex cross-cultural exercise and interpretation of census categories can be difficult.<sup>26</sup> The numbers used for this study were based on adjusted Australian Bureau of Statistics estimates following the 2011 Census and represent the best possible estimates available.<sup>27</sup> Similarly, reporting of Aboriginality of cases may not always have been accurate. Coding of Aboriginality in the Cancer Registry data relies principally on its capture in two settings: contact with publicly funded health services (whence it becomes available to the Registry via individual cancer-related hospital discharge records, or via individual search of the patient master index), and death registrations that are routinely linked to the Registry. At an individual level, it is not possible to determine

the degree of correspondence between Aboriginality determined in these health/mortality-related settings and that based on census information. The determination of Aboriginality in both these settings, however, is based on report either by the individual or relatives.

Sensitivity analyses were conducted to determine the effect of misreporting of Aboriginality on ASIRs and ASMRs. There are very little data on the extent of misclassification of Aboriginal status in either census or hospital data. A 2001 WA Health Department study found that the number of Aboriginal and/or Torres Strait Islander (ATSI) people recorded in hospital inpatient data is an understatement of the number of ATSI people admitted as patients, on average by about 15%;<sup>28</sup> a 15% under-reporting for either the census data or the cases for the sensitivity analyses was therefore used. For the ASIRs, the ranges for a 15% overestimation (under-reporting of census data) and underestimation (under-reporting of cases) were not large and were within the wide confidence intervals of the estimates. The adjusted 1994–2008 ASMR assuming 15% under-estimation of the Aboriginal population (denominator) was 3.6/100,000 and was still considerably larger than other international rates.

The most significant source of asbestos exposure for each case is determined by the Mesothelioma Register Committee, which takes information from all available sources into account, including duration of various employment and residential situations. This may not reflect all possible sources of exposure and exposure types, and we cannot be certain that the assigned exposure route was the actual cause of the disease. However, there is no difference in the method of collection of evidence between Aboriginal and non-Aboriginal people.

The Wittenoom area is the largest (by surface area) asbestos-contaminated site in the Southern Hemisphere, covering an area of 46,840 hectares.<sup>6</sup> In 1994, the WA Government determined that no systematic clean-up of the mine, town and surrounding areas would occur.<sup>8</sup> The management of public health risks was – and remains – confined to raising awareness to limit access to the area. However, despite the widespread contamination, Aboriginal people today continue to use the area for recreational and ceremonial activities. A 2010 archaeological and anthropological report<sup>9</sup> found that,

despite dislocation from the area due to the mining activities since the 1940s, the Banyjima people's desire to reconnect and rejuvenate cultural connection to the area was overwhelmingly evident. The traditional owners still frequent the area and do not use personal protective equipment during their stay.<sup>9</sup> The report indicates that ignorance of the degree of contamination and subsequent health effects has meant Aboriginal people have felt quite secure to continue to visit and use the area.<sup>9</sup> In 2013, a government education campaign commenced to warn the local people of the dangers of visiting the area but, as yet, there has been no evaluation of the effectiveness of that campaign.

The mining of blue asbestos in Wittenoom has been the major contributor to the high incidence rate of MM in WA Aboriginals. Unfortunately, further cases of MM in local Aboriginal people may develop because of historical exposure and ongoing access to highly contaminated lands.

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**Note:** An earlier version of this paper contained an error in Table 1. The order of the 'Histological subtype' category was incorrect.