

Risk of mesothelioma from exposure to crocidolite asbestos: a 1995 update of a South African mortality study

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Abstract

Objective—To find the risk of developing mesothelioma in a cohort born in 1916–36 in Prieska, Northern Cape Province, South Africa.

Methods—A birth cohort mortality study was carried out in a small town in the Northern Cape Province, South Africa, with a history of crocidolite asbestos mining and milling. The cohort comprised all white births registered in the magisterial district of Prieska from 1916 to 1936, inclusive (2390). Causes of death due to mesothelioma and other cancers as recorded on medical certificates of cause of death were investigated. Person-years analysis was used to calculate mortalities due to mesothelioma, other respiratory cancers, and other non-respiratory cancers. Proportional cancer mortalities were also calculated for mesothelioma and other specific neoplasms.

Results—The follow up rate for the cohort was 74.3% in 1995, and 683 traced members (38.6%) had died. Cause of death was unknown for 6.4% of deaths. There were 118 cases of cancer, 28 of them from mesothelioma, giving a cause specific mortality for mesothelioma of 277 (170–384) per 10⁶ person-years. The rates for men and women were 366 and 172 per 10⁶ person-years, respectively. The mortality for lung cancer (29 deaths) was 287 (135–436) per 10⁶ person-years, and that for other non-respiratory cancers (60 deaths) was 593 (442–745). Two cases of laryngeal and four of colon cancer were observed. All cancer mortality, mesothelioma, and lung cancer proportional cancer mortality ratios were increased.

Conclusion—The mortality for mesothelioma in men was twice that in women, probably because men were more likely to have had both occupational and environmental exposure to asbestos. Nevertheless, the mortality in women was still high and is probably indicative of the environmental exposure as white women were rarely employed in the asbestos industry in the Prieska area. Due to the long latency from first exposure to diagnosis of the neoplasm, the cause specific mortality in this cohort could be expected to increase rapidly over the next 10 years.

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Prieska is a small, remote town in South Africa, close to a crocidolite asbestos mining area that was productive from 1893 to the late 1960s. Twenty four crocidolite rich deposits had been identified in the Prieska magisterial district by 1930.¹ These were mined at various times from 1919–43 by the Cape Asbestos Company and from 1929 by smaller companies. A crushing mill was built in Prieska town in 1930, and residents were exposed to asbestos fibre emissions from the mill which was close to both the residential and business areas,² until at least 1964. Local residents, however, remember the mill working in the late 1970s. Other sources of exposure were the asbestos dumps (on which children played); spillage of fibres during transport; and tailings which were used for, among other things, surfacing roads and making bricks.³ The last major store of asbestos was removed from the town in 1982. Homes are still polluted through years of wind blown fibres accumulating in the ceilings.

Several studies have shown an increased risk of developing mesothelioma or respiratory cancer after occupational and environmental exposure to crocidolite.^{4–7}

Botha *et al*⁶ reported an annual death rate due to asbestosis or mesothelioma for white people of 542 per million for a high exposure crocidolite area (which included Prieska), 87 for a low exposure crocidolite area, and 24 in a control area. By comparison the rates for the coloured (mixed race) population were 573 per million and 215 per million in the high and low exposure areas respectively. The standardised mortality ratio (SMR) was increased for all cancers in both population groups and sexes. This was significant except for white women. The lung cancer SMR was moderately increased at 1.73 for white men, 1.87 for white women, and 1.28 and 2.47 for coloured men and women respectively. Significance was reached for white men and coloured women. An interesting result was the increase in the SMRs for stomach cancer and neoplasms of the digestive organs and peritoneum for both men and coloured women.

Sluis-Cremer *et al* showed a mesothelioma rate of 446 per million person-years for white men employed in crocidolite mining.⁷

Cases of mesothelioma induced by environmental (non-workplace) asbestos exposure are well documented, with domestic exposure due to relatives working with asbestos a common source.^{8–11} A recently published study from Australia estimates the incidence of mesothelioma due to environmental asbestos exposure in Wittenoom as 270 per million person-years.¹²

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Not surprisingly, an unusually large number of cases of mesothelioma among the residents of Prieska have been reported over the past few decades, which was the motivation for this study in which the risks of developing mesothelioma or other respiratory cancers were calculated for this community. Preliminary data were published in 1990²; this paper updates the findings to 1995.

Methods

SUBJECTS

This cohort mortality study included all white people whose births were registered in the magisterial district of Prieska in 1916–36. Subjects who were not white had to be excluded because of poor official records. The cohort was established by copying the birth register for the Prieska district for the selected years.

The unique national identity number and vital status of the 2390 cohort members was sought in the computerised population registry of the Department of Home Affairs. The registry contains the unique identification number, surname, all names, birth date, address, and if the person has died, the date of death and cause of death. This registry is organised by unique identification number but it can be searched also by surname and birth date. For each computerised record a physical file exists which contains original documents such as death registration and medical death certificates. Not all cohort members were entered into the computerised registry—namely, those who died before it was established in 1972, and those who had not obtained an identity document. In these cases, information was obtained by a manual search of the physical files.

The identity numbers were subsequently used to ascertain vital status throughout the follow up period. The identity numbers were periodically sent to the Department of Home Affairs, which provided copies of the medical certificate of death and the death register form of cohort members who had died.

If a person dies at the age of ≤ 10 , the name of one or both parents (or the guardian) is recorded on a form along with information such as place of birth and address, parents' names, and places of residence. These documents are completed when a person (usually a relative) informs a death registration officer about a death, and are bound in annual death registers according to the magisterial district where the death occurred. We manually searched the death registers of the Prieska magisterial district for deaths that occurred in cohort members during infancy or childhood. We examined the Prieska death registers (archived records) for the years of death 1917–46 (1936 plus 10 years). We were able to examine the birth registers from which the cohort was originally compiled to find whether the dead person belonged in the cohort.

Cohort members who were not entered into the Registry or who had left the area and died elsewhere (thus not entered into the Prieska death registers) are lost to follow up, unless

they obtained identity numbers through the course of the study.

DATA ANALYSIS

All deaths among white people that had been detected by the end of 1995 are included in the analysis. Descriptive statistics include a comparison of number of deaths within different age groups for specific causes of death; cancers are of particular interest.

Person-years analysis was used to calculate mortalities due to mesothelioma and other respiratory cancers (lung and bronchus). Person-years were the number of years from birth to death for deceased cohort members and the years from birth to the end of 1995 for those still living. Proportional cancer mortality ratios (PCMRs) for mesothelioma and other respiratory cancers were also calculated, with the white South African population as comparison.¹³ Sex specific and total expected numbers were calculated from people who had died at ≥ 30 so the age profile of the studied population and reference population were the same. The 95% confidence intervals (95% CIs) for the specific mortalities and PCMR analysis were calculated from the Poisson distribution.

Results

In the period 1917–36 a total of 5898 births were registered in the Prieska district. Of these 2390 (40.5%) were white, 2376 (40.3%) were coloured, 909 (15.4%) were black, and 16 (0.3%) were Asian (table 1). The population group of the remaining 207 births (3.5%) was not stated in the registers.

By the end of 1995 a total of 2410 members of the cohort were traced (table 1), most of whom were white (73.7%). Of the white people who were traced 38% had died. A disappointingly small proportion of cohort members who were not white could be traced, so analysis had to be restricted to white subjects.

As figure 1 shows, the age group with the highest proportion of deaths (44.8%) was mature adults, followed by infants (24.9%). The most common causes of death in infants, as stated on the death certificates, were complications of pregnancy, childbirth, and purpura (33%), followed by respiratory diseases such as pneumonia (17%), and other infectious and parasitic diseases (15%). All the deaths of children < 15 years of age (257) were identified by manually searching the death registers for the Prieska district. This considerably improved the tracing of the cohort, from 65% to 74%.

Table 1 Number of registered births, traced cohort members, and deaths (by population group)

	Registered births	Traced cohort members		Deaths in traced cohort members	
	n	n	%	n	%
White	2390	1776	74.3	683	38.4
Coloured	2376	510	21.6	367	72.1
Black	909	118	13.0	111	94.1
Asian	16	3	18.8	2	66.7
Unknown	207	3	0.0	0	—
Total	5898	2410	40.9	1163	48.2

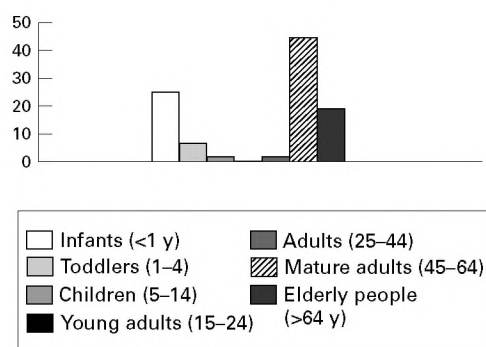


Figure 1 Percentage of deaths by age category in 683 white cohort members who had died by 1995.

By the end of 1995, 683 (38.4%) of the traced cohort members had died, the cause of death was unknown for only 6.4% of deaths. There were 118 cancer deaths. Except for one case of sarcoma in an infant, these cancers occurred in subjects >35 years (fig 2). Twenty eight deaths from mesothelioma (one peritoneal and the rest pleural) and 29 from lung cancers (lung or bronchus) were recorded. Other major sites for cancers were gastrointestinal (18 cases) and 21 of the genitourinary system. The remaining 21 cancers occurred in primary sites such as lymphatic and haematopoietic tissue; lip, mouth, and pharynx; larynx (two men); skin; brain; and six cases had an unspecified primary site.

The mean and range of ages of the subjects who died of mesothelioma or lung cancer were very similar: 59.8 (range 43–74) years and 60.5 (range 40–72) years, respectively. The male to female ratios for mesothelioma and lung cancers were 2.5 and 3 respectively.

Table 2 shows the cancer rates at age ≥ 30 , for the years 1975–94.

The rate for all cancers for men was 1557 per 10^6 , compared with 689 for women; a 2.3 times lower rate.

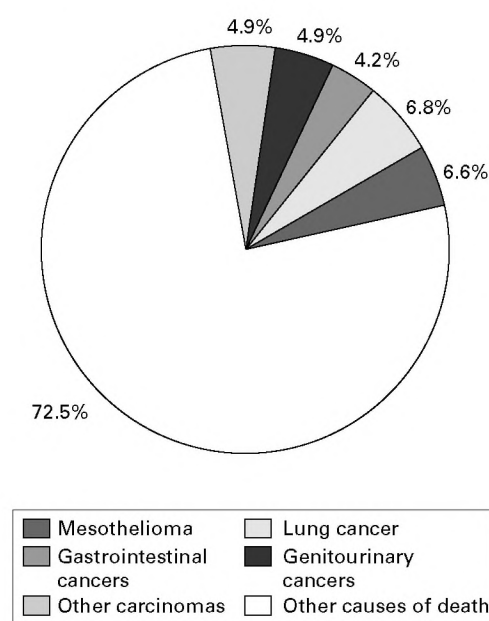


Figure 2 Proportion of cancer deaths in 415 deceased cohort members of ≥ 30 years.

Table 2 Mortalities for all cancers, mesothelioma, and lung cancer for subjects ≥ 30 (1975–95)

Cancer type	Men	Women	Total
Person-years	54 598.5	46 472.2	101 071
All cancers:			
Cases (n)	85	32	117
Rate*	1557	689	1158
95% CI	1223 to 1891	449 to 929	952 to 1364
Mesothelioma:			
Cases (n)	20	8	28
Rate*	366	172	277
95% CI	202 to 530	48 to 296	170 to 384
Lung cancer:			
Cases (n)	22	7	29
Rate*	403	151	287
95% CI	239 to 567	27 to 274	135 to 436

*Rates are in 10^6 person-years.

The mortality for mesothelioma was 277 per 10^6 person-years (95% CI 170 to 384), but the rate for men was twice that for women: 366 and 172 per 10^6 person-years, respectively. Again, most deaths due to lung cancers (lung and bronchus) were in men (76%), with the rate for men almost three times that for women, and was very similar to those for mesothelioma.

Proportional cancer mortality ratios are shown in table 3.

The PCMRs for mesothelioma were significantly increased for all cases at 31.11 (95% CI 20.7 to 43.6) and for men and women at 18.2 (95% CI 11.1 to 27.7), and 26.7 (11.5 to 52.5), respectively. Although the PCMRs for lung cancers were also increased, these increases were not significant. The two cases of laryngeal cancer, both in men, produced a ratio 1.8 for all subjects and 1.7 for men. Cancer of the colon produced PCMRs <1 . Seventeen cohort members, 15 men and two women, died of cancers of the digestive system, with PCMRs of 0.5, 0.7, and 0.4 for all subjects, men, and women respectively. The deficit of cases was significant for all digestive cancers (0.5, 95% CI 0.3 to 0.8) but not for all colon cancers (0.5, 95% CI 0.1 to 1.4). The PCMRs were not calculated for the remaining 41 cases of cancer as these cancers were thought not to be associated with exposure to asbestos.

Table 3 Proportional cancer mortality ratio (PCMR) analysis for all cancers, mesothelioma, lung, laryngeal, and colon cancers by sex, in subjects ≥ 30 years who died between 1975–95

	Observed n	Expected n	PCMR	
			Rate	95% CI
All cancers:				
Men	86	59.6	1.4	1.1 to 1.8
Women	32	20.5	1.6	1.1 to 2.2
Total	117	79.8	1.5	1.2 to 1.7
Mesothelioma:				
Men	20	1.1	18.2	11.1 to 27.7
Women	8	0.3	26.7	11.5 to 52.5
Total	28	0.9	31.1	20.7 to 43.6
Lung:				
Men	22	20.5	1.1	0.7 to 1.6
Women	7	4.8	1.5	0.6 to 3.0
Total	29	23.3	1.2	0.8 to 1.8
Larynx:				
Men	2	1.2	1.7	0.2 to 6.0
Women	—	0.1	—	—
Total	2	1.1	1.8	0.2 to 6.5
Colon:				
Men	3	3.5	0.9	0.2 to 2.5
Women	1	2.9	0.3	0.01 to 1.9
Total	4	7.3	0.5	0.1 to 1.4

Discussion

This study shows that mortalities due to mesothelioma in the Prieska area are very high at 277 per 10⁶ person-years overall and 366 and 172 per 10⁶ for men and women respectively. Partly as a consequence, the overall proportion of deaths due to cancer for cohort members ≥ 30 years was high at 28.2% (117/415). The proportion of all lung cancer deaths was moderately increased in the cohort relative to the general population.

The PCMR analysis showed a deficit of cancer of the gastrointestinal tract. This could be explained by a see-saw effect with raised ratios of one cancer (mesothelioma) resulting in lower ratios for others.

In the white population of South Africa, the latest available reported rate for histologically diagnosed mesothelioma is 37.0 and 16.3 per million in men and women respectively.¹⁴ Zwi *et al*¹⁵ calculated the standardised annual incidence of mesothelioma among white people >15 years to be 32.9 per 10⁶ for men and 9.9 per 10⁶ for women. The highest national rates reported elsewhere in the world were in the United States,¹⁶ and are much less than South Africa at 12.4 and 2.4 per 10⁶ for men and women respectively. By comparison, the rates in Prieska are 348 and 172 (10⁶ person-years) for men and women respectively, roughly 10 times the magnitude of the national incidence¹⁵ and National Cancer Registry.¹⁴ The Prieska rates are similar to those found in Wittenoom for past residents of the crocidolite mining town who did not have occupational exposure to asbestos—namely, 267 per 10⁶ person-years.¹²

For white South Africans the reported crude mortality for lung cancer in men is 199 per million and for women 92.5 per million. In this birth cohort the mortality for carcinomas of the lung and bronchus was 287 per 10⁶ person-years, very similar to that for mesothelioma, 277 per 10⁶. As asbestos is associated with the development of both mesothelioma and lung cancers, these high rates indicate the severity of the consequences of past crocidolite exposure.

There are two main limitations in this study: the cohort was restricted to white subjects; and the extent of ascertainment of cases of disease related to asbestos is uncertain in both the study subjects and reference population. Underascertainment is possible as the diagnosis of a specific cancer may not have been made and thus not recorded as the cause of death. On the other hand, overascertainment of mesothelioma in the study population is possible if the doctors were influenced to diagnose mesothelioma because of a history of exposure to crocidolite.

It is unfortunate that the historical system of archiving deaths in the Department of Home Affairs restricted our mortality analyses to white subjects, because the different population groups probably had different profiles of exposure to asbestos. According to reports of the government mining engineer (the statutory authority), during the 1940s and 1950s most asbestos miners, cobblers, and mill workers in the crocidolite fields were coloured, and

mortalities in this population group would incorporate the risk from occupational exposure. However, a predominance of coloured workers may not have pertained to Prieska. Botha *et al*⁶ reported on the racial breakdown of employees of the asbestos industry for the period 1929–60 in certain districts such as Kuruman, Prieska, and Hay, but the source of these data is not clear. It seems that in Prieska more white than coloured men were employed (4% *v* 2.1%). By comparison, 2.2% of coloured women worked in the industry and only 0.2% of white women. The low rate of occupational exposure in white women is borne out by a recently conducted interview with a woman who worked as an asbestos mill manager in Prieska (Snyder J, personal communication, Prieska, 1999) and by archived data acquired on employment figures of the Prieska mill and mines in the Prieska Magisterial District¹⁷: only one woman worker was identified and she was not born in Prieska, and thus was not part of the cohort. This scarcity of white women among asbestos workers is important to this study as white women were likely to have had purely environmental exposure. We suspect, therefore, that rates of mesothelioma for white women are as a consequence of purely environmental exposure to crocidolite. The rates in men are more likely to incorporate both occupational and environmental influences, but we do not yet know what proportion of men in the cohort died from work with asbestos as a survey of study members and their relatives is still under way.

Of the cohort of 2390, 74% had been traced up to 31 December 1995; a similar rate (71.4%) was reported in the Whitenoom study.¹² The vital status was thus unknown for 614 of our subjects, but this may improve as deaths increase in this aging cohort resulting in more death certificates being obtained.

Some misclassification due to incorrect cause of death recorded on death certificates is likely. For example, some of the gastrointestinal cancers may have been peritoneal mesotheliomas, or some of the pleural mesotheliomas could have been adenocarcinomas of the lung. The size of this bias, should it exist, cannot be estimated. However, accuracy of cause of death as recorded on the death certificates was compared with necropsy findings and found to be fairly accurate for cancers in a South African community of miners and former miners.¹⁸ For example, death certificate diagnosis of lung cancer and mesothelioma had a positive predictive value of 83.3 (68.6–93.0).

All the deaths of children <15 years of age (213) were identified by manually searching the death registers for the Prieska district. This increased the follow up rate by 9%. We recommend that researchers undertaking cohort studies of mortality in South Africa, especially those in young children or birth cohorts, make use of this method of identifying cases that might otherwise be lost to follow up.

Conclusion

The mortalities for mesothelioma were very high: 366 and 172 per million person-years.

The higher rates in men are probably accounted for by occupational exposure to asbestos experienced by some of them. Nevertheless, the mortality in women was still high and probably a consequence of environmental exposure. Due to the long latent period of the development of this neoplasm, and continuing high production of crocidolite asbestos until the late 1970s¹⁹ the cause specific mortality in this cohort can be expected to increase rapidly over the next 10 years.

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