

# Environmental exposure, social class, and cancer risk

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Exposure to a variety of environmental factors associated with cancer occurrence varies by social class. These factors include air pollutants (SO<sub>2</sub>, NO<sub>2</sub>, total suspended particulates, etc.), toxic waste hazards, and ionizing and other radiation. Heavy environmental pollution has been associated with an increased risk of some cancers and in particular lung cancer. There is limited evidence suggesting that individuals from lower social classes are exposed to higher levels of environmental pollutants than are individuals from higher social classes. This may be due to the placement of new sources of pollution or of toxic processes in disadvantaged areas, or to the selective migration of the poorer sectors of society to these areas. The available data do not allow any conclusion on the possible contribution of exposure to environmental pollution to social class differences in cancer occurrence. Exposure to ultraviolet (UV) radiation, principally from sunlight, is modified strongly by personal behaviours such as choice of recreation and use of protective clothing. Those in outdoor occupations are likely to receive the highest cumulative exposure to UV radiation. There is no clear evidence from recent survey research in Australia and North America that socioeconomic factors are strongly related to non-occupational exposure to UV radiation. Information is lacking on the influence of socioeconomic status on sun exposure in other parts of the world. There is little information on the social distribution of exposure to ionizing radiation.

The concept of environment is often used in a broad sense, to comprise all factors unrelated to the genetic make-up of an individual, such as occupation, nutrition, lifestyle and reproductive habits, infections and so on. In this broad sense, the environment is likely to be responsible for the majority of the cases of cancer in humans (Tomatis *et al.*, 1990). Most commonly, however, the concept of environment is used in a narrower sense, to cover only factors related to the place where people live, and over which each individual has little control. This paper addresses the relationship between cancer risk, social class and environmental factors considered in this narrow sense.

At present, our knowledge of the role of the environment in human cancer covers four major groups of factors: air pollutants, water pollutants, non-ionizing [mainly ultraviolet (UV)] radiation and ionizing radiation (Table 1). In this chapter, the evidence linking cancer risk, social class and these groups of factors is discussed in detail.

## Environmental pollution

### *Cancer risk from environmental pollution*

Most of the evidence on the association between

environmental (mainly air and water) pollution and cancer comes from descriptive or ecological studies comparing cancer rates in populations exposed to different levels of pollution, such as urban and rural populations (Simonato & Pershagen, 1993).

The interpretation of these epidemiological studies is complicated by the low quality of information on past exposure – a problem common to most investigations on the effects of environmental exposures (Hatch & Thomas, 1993). Most studies on air pollution and cancer suffer in addition from lack of specificity of outcome, since the organ most heavily affected is the lung, and the overwhelming cause of lung cancer in most populations is tobacco smoking; the latter may therefore be an important confounder of the association between air pollution and cancer.

A clear association between environmental pollution and human cancer has been shown in analytical epidemiological studies in several cases of heavy pollution, such as drinking-water contamination from arsenic in Taiwan (Chiou *et al.*, 1995), air pollution from residential and industrial sources (mainly metal smelting) in Upper Silesia,

Poland (Jedrychowski *et al.*, 1990), and contamination with dioxins in Seveso, Italy (Bertazzi *et al.*, 1993). At present, however, the evidence of an increased risk of cancer (mainly for the lung) following exposure to light or moderate levels of pollution, such as those to which many industrial populations are exposed, is still inconclusive (Simonato &

Pershagen, 1993). Indoor air pollution may also represent a cancer hazard; in particular, non-smokers exposed to environmental tobacco smoke (Tredaniel *et al.*, 1993) and people (mainly women) exposed to large amounts of combustion fumes from cooking and heating (Xu *et al.*, 1989) have been shown to be at increased risk of lung cancer.

**Table 1. Environmental agents and exposures known or suspected to cause cancer in humans<sup>a</sup>**

Agent/exposure	Target organ <sup>b</sup>	Strength of evidence <sup>c</sup>
<b>Air pollutants</b>		
Erionite	Lung, pleura	1
Asbestos	Lung, pleura	1
Polycyclic aromatic hydrocarbons <sup>d</sup>	–	E
Coal-tar pitches	Skin, lung, bladder	1
Coal tars	Skin, lung	1
Mineral oils (untreated and mildly treated)	Skin	1
Shale oils	Skin	1
Soots	Skin, lung	1
Creosotes	(Skin)	2A
Diesel engine exhaust	(Lung, bladder)	2A
Bitumens, extracts of steam-refined and air-refined	(Lung, skin)	2B
Carbon-black extracts	(Bladder)	2B
Engine exhaust, gasoline	(Lung)	2B
Fuel oils, residual (heavy)	(Skin, lung)	2B
<b>Water pollutants</b>		
Arsenic	Skin, lung	1
Chlorination by-products	(Bladder)	S
Nitrate and nitrite	(Oesophagus, stomach)	S
<b>Ionizing radiation</b>		
Radon and its decay products	Lung	1
Radium, thorium	Bone	E
X-rays	Leukaemia, breast, thyroid, others	E
<b>Non-ionizing radiation</b>		
Solar radiation	Skin	1
Ultraviolet radiation A	(Skin)	2A
Ultraviolet radiation B	(Skin)	2A
Ultraviolet radiation C	(Skin)	2A
Use of sunlamps and sunbeds	(Skin)	2A
Electric and magnetic fields	(Leukaemia)	S

<sup>a</sup>Agents and exposures occurring mainly in occupational settings, as well as medicines, are excluded.

<sup>b</sup>Suspected target organs are given in parentheses.

<sup>c</sup>IARC Monographs evaluations (IARC, 1972–1995) are reported wherever available (1, human carcinogen; 2A, probable human carcinogen; 2B, possible human carcinogen); otherwise 'E' and 'S' are used (E, established carcinogen; S, suspected carcinogen).

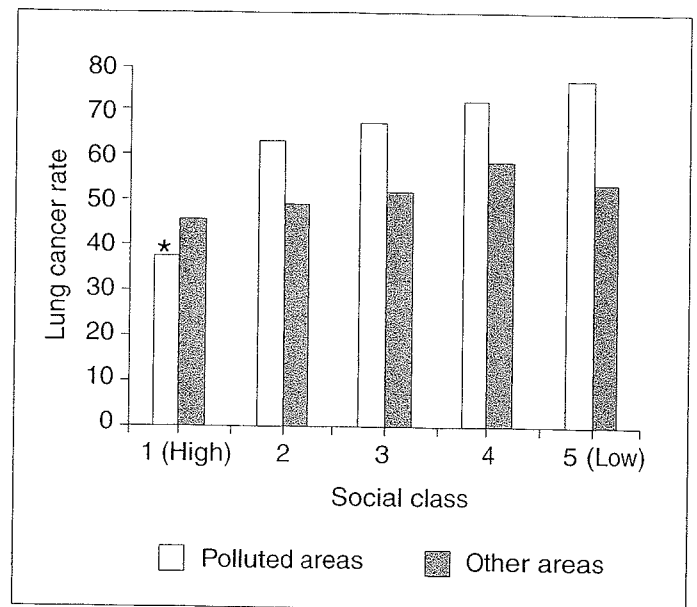
<sup>d</sup>Only mixtures of polycyclic aromatic hydrocarbons are listed separately; several individual hydrocarbons have been classified in IARC Groups 2A and 2B.

Table 1 shows the carcinogenicity of environmental pollutants, some of which have been evaluated within the IARC *Monographs* programme as established or probable carcinogens (IARC, 1972–1995). Many estimates of the proportion of cancers due to air and water pollution are in the range of 0.5–2% of all cancers; for example, Doll and Peto (1981) estimated that pollution was responsible for 2% of cancers in the United States of America, with air pollution causing half of these. In specific situations, however, the share of cancers due to pollution may be higher; for example, in the study conducted in Upper Silesia, the risk of lung cancer attributed to air pollution among women was 10% (Jedrychowski *et al.*, 1990).

#### Role of social class

It is likely that exposure to environmental pollution is higher among lower social classes than among higher social classes; some of the differences in cancer risk among social classes (see the chapter by Faggiano *et al.* in this book) may therefore be attributed to environmental pollution. Increased environmental exposure to carcinogens in lower social classes may result from residence in neighbourhoods with higher air pollution and lack of unpolluted (for example, bottled) drinking-water, more time spent in outdoor polluted workplaces, difficulty in moving from contaminated areas of the cities, use of less efficient cooking and heating systems (Goldstein *et al.*, 1986, 1988), and higher probability of living with a smoker. Although differences in living style such as these are obviously related to social class, there is little direct evidence on their existence and magnitude.

Data from the USA on social-class-related differences in air pollution exposure have been reviewed by Sexton *et al.* (1993). At the 1990 USA census, Blacks (86%) and Hispanics (91%) were more likely to live in urban areas than Whites (70%); the same ethnic difference was seen in the proportion of the population living in areas out of compliance with the USA Environmental Protection Agency air quality criteria – for particulate matter this proportion was 15% for Whites, 17% for Blacks and 34% for Hispanics (Sexton *et al.*, 1993). In an ecological study of 34 areas of the United Kingdom, a strong positive correlation was found between social class index and domestic air pollution (Nixon & Carpenter, 1974). The opposite result, however, was



**Figure 1.** Age-adjusted annual lung cancer rates (per 100 000) in white men in Los Angeles county, USA, for 1968–1970 (mortality) and 1972 (incidence). Modified from Henderson *et al.*, 1975. The data indicated by an asterisk are based on five cases or deaths.

found in an analysis of total suspended particulate (TSP) and socioeconomic status in census tracts in Harris County, Texas, USA, in which a strong negative correlation was found (Buffler *et al.*, 1989).

Henderson *et al.* (1975) analysed lung cancer incidence (1972) and mortality (1968–1970) in areas of Los Angeles county, California, USA with high mortality from lung cancer and high air pollution, and in the rest of the county. This study showed consistently higher rates in lower social classes and in the most polluted parts of the county (Fig. 1), the difference between the polluted and the less polluted parts being greatest in the lowest social class. The overall rate ratios were 1.33 for air pollution and 1.26 for social class (classes 4 and 5 versus classes 1 and 2); when men from classes 1 and 2 living in the less polluted areas were taken as reference, men from classes 4 and 5 living in more polluted areas had a rate ratio of 1.53. Overall, this study suggests that air pollution had in this population an effect on lung cancer rate as large as that of other factors related to social class.

More data are available on social class or ethnic group differences in exposure to non-carcinogenic air pollutants, such as indoor lead (Agency for Toxic Substance and Disease Registry, 1988) and indoor carbon monoxide (Schwab, 1990). These studies consistently showed a higher exposure in lower

social classes, although the magnitude of the difference varied greatly.

Limited data are available on differences in exposure to water pollution; for example, in the USA, hazardous waste sites and in particular sites classified in the National Priority List, many of which entail contamination of ground water, occur more frequently in counties classified as rural poor counties at the 1980 census than in other counties (Calderon *et al.*, 1993). Similar data were not available on populations exposed to carcinogens from contamination of soil or other media.

### UV radiation

#### *Cancer risk from UV radiation*

UV radiation is the major environmental cause of skin cancers, both melanocytic and non-melanocytic (squamous-cell and basal-cell carcinomas). Radiation in the middle of the UV range (UVB 280–320 nm) is the wavelength principally responsible for sunburning and skin cancer (IARC, 1992).

Melanoma is one of the few neoplasms that occurs more commonly in groups of higher socioeconomic status than in less advantaged groups. This pattern has been observed in many countries (see the chapter by Faggiano *et al.* in this book), and is thought to be principally due to differences in the quality and timing of exposures to intense sunlight (Elwood *et al.*, 1985). In contrast, squamous and basal cell cancers of the skin are associated with cumulative exposures to UV radiation. These cancers are generally not included in disease registers, and there are few good incidence studies of socioeconomic-related risk factors. However, research in Australia, where rates of non-melanocytic skin cancers are particularly high (the lifetime risk among white-skinned Australians is more than two in three), has shown that increasing age, male sex, tendency to sunburn and outdoor occupation are positively related to disease risk (Marks *et al.*, 1989).

Photographs and paintings show that in European cultures those who could afford to avoid the sun generally did so, by choice of clothing and recreation, until the second and third decades of this century. Then the prevailing models of attractiveness changed, tanning was favoured, and the health-giving properties of sunlight were emphasized. Increasingly, a suntan was regarded as a symbol of success and well-being (Arthey & Clarke, 1995). There is some evidence that attitudes are changing

again – a survey of Australian women's magazines between 1982 and 1991 found a reduction in the proportion of models with a deep tan (Chapman *et al.*, 1992).

#### *Role of social class*

In many parts of the world agriculture remains the livelihood and means of subsistence for the bulk of the population. As a consequence, exposure to UV radiation in these settings may be said to be still predominantly occupational. Elsewhere there has been a marked reduction in the number of people employed in outdoor work, such as agriculture, construction and transport, with increasing mechanization and growth of the manufacturing, service and information industries. However, there remains a substantial proportion of the workforce that is exposed to UV radiation as part of their job. For example, the New Zealand census findings for 1986 showed that approximately 24% of males and 9% of females in the labour force were classified as full-time outdoor workers (New Zealand Department of Statistics, 1988). There are few detailed data on sun exposures due to work outdoors, but in mid-latitude countries such as New Zealand and Australia unprotected workers may experience high levels of UV radiation – a survey of telephone-line staff in Australia in 1990 found that 48% did not use hats and 20% commonly wore sleeveless shirts, singlets or no shirt at all when working (Borland *et al.*, 1991). In general, outdoor workers are more often from low social class than are other workers.

In industrialized and developing countries, exposure to sunlight outside work – so-called recreational exposure – has become increasingly important as a source of UV radiation for most socioeconomic groups. The relation of sun exposure to social factors is likely to vary between countries, and over time, depending on fashions, income differentials and opportunities for outdoor recreation. Most of the studies available have come from Australia, where skin cancer rates are the highest in the world, and good research on suntanning and sun exposure has been carried out. However, the findings on social class differentials (or their absence) should be extrapolated to other countries with caution.

In Victoria, Australia, household surveys are carried out each year to obtain information on knowledge and attitudes to suntanning and sun ex-

posure, and sun-protection behaviour (Hill *et al.*, 1990, 1993). The surveys include a representative sample of the population aged 14 years and over, and socioeconomic status is measured by the occupational status of the chief income earner in the household. The studies have found little difference in sun-protective behaviours (use of shade, hats and covering clothing) by socioeconomic status, although those from lower blue-collar and lower white-collar households were less likely to report using topical sunscreens (Segan & Borland, 1994). Awareness of public health programmes concerned with sun exposure and skin cancer was generally greater among upper white-collar and upper blue-collar households, and the strongest pro-tan beliefs were expressed by those from households of lower socioeconomic status. However, these differences were not reflected in sun-protective behaviours or inferred doses of UV radiation. For example, there were no differences apparent by socioeconomic status or educational level in the proportion of respondents who chose to stay out of the sun during the summer. Nor were there differences in the frequency of self-reported sunburn; there was a strong age effect (younger people were most likely to report sunburn in the preceding summer) and men reported sunburn more often than women, but there were no associations with socioeconomic status or educational attainment.

In South Australia, where similar research has been carried out, groups of higher socioeconomic status were found to be better informed in some regards, but the association of socioeconomic status and knowledge of sun exposure and appropriate protection behaviours was not strong (South Australian Omnibus Health Survey, unpublished data). Some differences in the use of topical sunscreens and protective clothing were apparent (for example, 57% of individuals in the highest socioeconomic status group reported that they usually or almost always wore a hat outdoors in the summer, compared with 43% of persons in the lowest socioeconomic status group). Except for the lowest rank socioeconomic status group, no consistent associations between social factors and sun exposure were observed.

Sun exposure in childhood and adolescence may be particularly important in the etiology of melanoma. Studies in New South Wales found that only a minority of high-school students took any delib-

erate measures to restrict sun exposure during summer, such as wearing a hat, applying a sunscreen, or seeking shade (Cockburn *et al.*, 1989). Smoking status and area of residence were predictors of sun-protection behaviour, suggesting an association of socioeconomic status and UV radiation exposure. The number of melanocytic nevi on the skin is thought to be a guide to the frequency of exposure to intense sunlight in early life, and is related to age, ethnic background, hair colour, ability to tan and propensity to sunburn. After adjustment for these factors, a Western Australian study found no association between nevi count in children aged 5–12 years and mother's level of schooling (English & Armstrong, 1994).

The survey in Victoria has found that socioeconomic status is weakly related to knowledge and attitudes concerning what is regarded as 'healthy' sun exposure, but there is no clear indication of differences between social groups in terms of how people behave, or the frequency of intense sun exposures (Segan & Borland, 1994). This is not due to a lack of sunshine or rarity of health outcomes – approximately 50% of Victoria respondents reported sunburn, and about a third of these reported burns that led to persisting tenderness and blistering. The results are unlikely to be a chance outcome, as consistent findings have been observed in multiple surveys involving thousands of respondents. It may be that the apparent differences in beliefs and knowledge are a reporting artifact, or that the responses elicited by surveys of this kind bear no strong relation to actual sun-protective behaviour. Alternatively, there may be a relation, but one that is not immediately apparent, and differences in behaviours may emerge in the future as individuals of upper socioeconomic status move more rapidly to adopt new norms.

Little has been published on other exposures to UV radiation, such as from use of suntanning beds and UV lamps, although these may be significant sources of skin-damaging radiation (IARC, 1992). A survey of adults in the USA found that tanning-bed users were more likely to be female and to be more knowledgeable about the long-term effects of UV radiation, but knowledge of hazards was unrelated to educational attainment (Mawn & Fleischer, 1993). A survey in Victoria, Australia in 1993 enquired about the use of 'tan accelerators', skin products that are reputed to decrease the sun exposure required to

obtain a suntan: 8% of the sample reported using such an agent, women more so than men, but there were no clear relations with age, socioeconomic status or education (Segan & Borland, 1994).

### Ionizing radiation

Ionizing radiation is a cause of leukaemia, myeloma and several solid tumours, notably breast, lung, bone and thyroid cancer (Tomatis, 1990). Apart from lung cancer, whose pattern is mainly due to characteristics of tobacco smoking, these tumours show a weaker social gradient than other neoplasms, and in some cases the rates are greater in high than in low socioeconomic groups (see the chapter by Faggiano *et al.* in this book).

The information on radiation and cancer comes chiefly from studies on four groups of exposed individuals: atomic bomb survivors, occupationally exposed workers (mainly miners and nuclear and medical workers), patients treated with radiotherapy for malignant or benign conditions, and subjects living in houses with high exposure to radon and its decay products.

These studies have a better definition of dose than studies done in other areas of epidemiology; this is mainly due to the availability of historical exposure records for many groups known to be exposed to ionizing radiation. A consequence of this situation is that less attention has traditionally been paid in these studies as compared with other areas of research to other factors that may influence the exposure, such as social class. Direct information is lacking on differences in radiation exposure by social class, except for a study on lung cancer risk following domestic exposure to radon, which suggested that education may act as a confounder (Latourneau *et al.*, 1994).

The pattern of occupations entailing exposure to ionizing radiation, however, provides some indirect evidence against the hypothesis of a strong role of exposure to ionizing radiation in determining social-class-related differences in cancer risk. The proportion of miners exposed to high levels of radon is relatively low (IARC, 1988), and many other occupations entailing exposure to ionizing radiation, such as nuclear industry worker, radiologist and radiological nurse, include a high proportion of white-collar occupations. Indoor exposure to radon depends on the geological characteristics of the soil underlying houses, on their distance from the soil

and on the ventilation of the rooms. Although direct evidence is lacking, it is plausible that people from lower socioeconomic groups in many countries live in dwellings with higher natural ventilation than those of people from higher socioeconomic groups, suggesting an inverse relationship between social class and radon exposure.

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