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A mortality study of cadmium workers in the United Kingdom

by George Kazantzis, PhD, Benedict G Armstrong, MSc [1]

KAZANTZIS G, ARMSTRONG BG. A mortality study of cadmium workers in the United Kingdom. *Scand j work environ health* 8 (1982): suppl 1, 157—160. A cohort mortality study of cadmium workers in the United Kingdom is in progress. In this report the design of the study is presented, and some features of the study population are described. The procedure for assessing exposures in the study is discussed.

Key terms: cohort study, occupational mortality.

A study is in progress to obtain more information on the pattern of mortality among workers exposed to cadmium compounds. Long-term occupational exposure to cadmium has given rise mainly to respiratory and renal effects. Chronic obstructive respiratory disease and emphysema have been described, but only for workers with heavy past exposure to cadmium oxide fumes or dust (3). Renal tubular dysfunction has also been observed, giving rise in some cases, to the long-term sequelae of glomerular impairment, renal stone formation, or osteomalacia (4). However, the effect of respiratory and renal dysfunction on the life expectancy of the population at risk has been little investigated. It has been suggested that exposure to cadmium has contributed to the development of prostatic and, possibly, lung cancer, but the epidemiologic studies on carcinogenicity are inconclusive because of the small number of workers involved (7). In this study, the mortality of cadmium-exposed workers in England and Wales is therefore being looked at with special reference to respiratory and renal causes, hypertension, and cancer.

Before a suitable study population could be obtained, it was considered necessary to include as large a group of workers exposed to cadmium compounds as was possible within the constraints of the available resources. Furthermore, it was considered desirable that such a study population should be drawn from a wide geographic area to allow for regional differences in mortality, and from diverse industries involving exposure to cadmium so that the effects of the confounding variables present in any one industry would be minimized. Such confounding variables include exposure to other toxic metals, eg, lead, arsenic, and nickel. Because of the possible long-term effects of cadmium on health, it was also necessary to include workers whose initial exposure to cadmium had occurred as far back in time as possible, these workers to be followed to death or to the termination of the study. Workers with both heavy and light past exposure were required to facilitate the internal comparison between exposure categories.

Methods

A steering committee [2] was formed to advise the planning of the study, which

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was instrumental in locating the relevant industries, in obtaining their voluntary co-operation, and in helping to trace information on past exposure. The approval of unions was sought, and the work was co-ordinated through the TUC Centenary Institute of Occupational Health. All companies approached agreed to participate. A register of workers which included identifying particulars, and dates of entering and leaving cadmium-exposed employment, was compiled from employment records supplemented by medical records. Job categories and job changes were recorded when possible. Vital status is being ascertained through the Office of Population Censuses and Surveys (OPCS) and causes of death are being coded by the OPCS according to the Eighth Revision of the International Classification of Diseases.

All men who worked on the shop floor for a minimal period of 1 a in a plant while a cadmium process was being used qualified for inclusion in the study. Certain clearly defined groups which have had no occupational exposure to cadmium and men joining as members of staff were excluded. The study is being performed in two parts; initially, men born before 1940 who joined the company before 1970 are being traced through to the present. At the same time younger workers and those who joined the company between 1970 and 1978 who completed 1 a of service have been added to the register for tracing in the future. Those workers in the former group, alive in 1980, will of course continue to have their vital status monitored by OPCS. The data from this cohort study will be evaluated with a person-years at risk analysis (1), the technique of regression models for life tables (2), and a case-referent analysis (5).

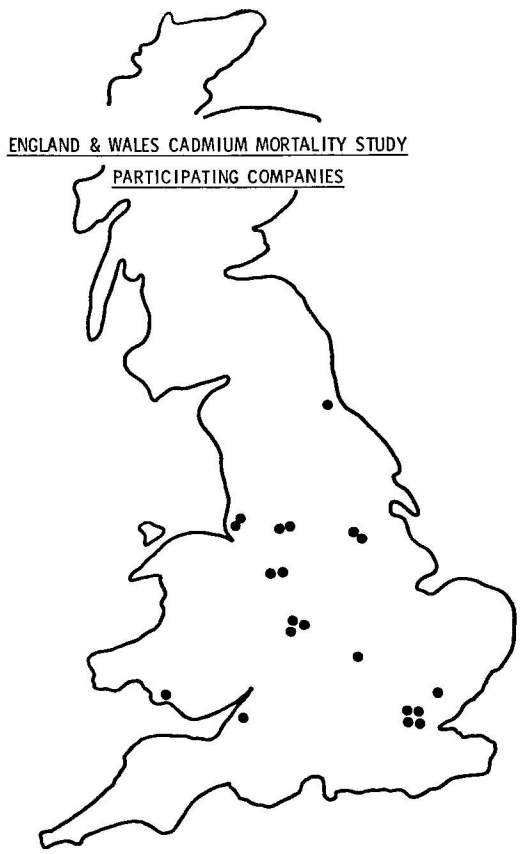

Fig 1. Location of companies participating in this mortality study of cadmium workers in the United Kingdom.

Study population

The geographic distribution of the companies included in the study is shown in fig 1. The study population was drawn from one primary production plant and from the major manufacturers of copper-cadmium and low melting point alloys, from cadmium pigment producers, from producers of cadmium-based stabilizers used in plastics, and from the nickel-cadmium battery industry. Most of the companies manufacturing cadmium-based pigments and plastic stabilizers also produce cadmium oxide for use in the plating industry and elsewhere. Cadmium platers were not included.

In those plants where cadmium was first used in the earlier part of the century, complete records were not always available. The population included in the present study inevitably excludes those workers leaving before the time covered by the record system. There will be a survivor bias in the cross-section of workers included in such a sample by virtue of their being current workers at the time when the record system began. These workers are included in our population, but must be distinguished in an analysis from those beginning work after that time.

The number of workers so far identified in each of these groupings is shown in table 1. In this population of 7,131 workers, to date 1,105 deaths have been traced

and 4,007 persons are known to be alive. We examined the distribution of the 1,105 deaths by cause and found no gross differences from the national pattern, but analysis will have to await completion of the returns from the OPCS, as there is no reason to believe that those deaths received so far are a representative sample. Altogether, we expect about 2,000 deaths in this population. A group of copper-cadmium alloy workers and one of nickel-cadmium battery workers has already been investigated by Holden (3) and Sorahan (6), respectively (table 2). The relevant data from these two groups have been made available to us for the purpose of obtaining an overall pattern of mortality among the cadmium-exposed workers who have been studied in the United Kingdom.

Assessments of exposure

The comparison of the mortality rate of an industrial population with that of national rates, as with the calculation of standardized mortality ratios, is subject to many known difficulties. Some of these difficulties may be avoided with comparisons of mortality experience within the study population. How sensitive such internal comparisons are as tests of cadmium effects depends on the accuracy with which it is possible to assess the exposure of workers in the study.

Changes in the appreciation of cadmium as a health hazard and consequently changes in hygienic standards for cadmium may be expected to influence levels of exposure. Some of these changes are shown in table 3. Environmental measurements

Table 1. Newly enumerated study population.

Industry	Number of workers
Primary production	4,538
Copper-cadmium alloys	586
Silver-cadmium alloys	1,034
Pigments + oxide	515
Stabilizers	458
Total	7,131

Table 2. Total study population.

Group	Number of workers
Holden 1980 (3) (copper-cadmium alloys)	1,277
Sorahan 1981 (6) (nickel-cadmium batteries)	1,323
Newly enumerated	7,131
Total	9,731

Table 3. Influence on cadmium exposure levels.

Hygiene limits	Other influences
	1940 Wartime blackout
1946 Maximum allowable concentration (MAC) for cadmium 0.1 mg/m³	
1948 Threshold limit value (TLV) for cadmium 0.1 mg/m³	
1954 TLV for cadmium oxide fume 0.1 mg/m³	
	1956 Cadmium poisoning made a prescribed disease in Britain
1965 TLV for cadmium metal dust and soluble salts 0.2 mg/m³	
	1967 Cadmium poisoning made a notifiable disease in Britain
	1968 Personal sampling introduced about this time
1970 Ceiling limit for oxide fume 0.2 mg/m³	
1974 TLV for metal dust and salts 0.05 mg/m³	1974 Cadmium oxide production designated A1 carcinogen by the American Conference of Governmental Industrial Hygienists (ACGIH)
	1976 Cadmium oxide production designated A2 carcinogen by the ACGIH
1979 Short-term exposure level (STEL) for cadmium dusts and salts 0.2 mg/m³	
	1980 A2 designation removed by the ACGIH

of cadmium have been made at many of the plants included in the study, but they go back, at the most, 30 a. Biological monitoring of urinary and blood cadmium levels has also been carried out, but again, in recent years only. During the earlier era of higher cadmium exposure, no environmental or biological measurements were made. With the aid of discussions with hygienists and those familiar with earlier processes and work conditions, however, approximate estimates of typical cadmium exposures for jobs over this time period may be made. From these assessments, approximate cumulative exposure or other aggregates of exposure may be computed for each worker. This information may be used to divide the population into groups according to exposure, or it may be applied directly in an appropriate mortality analysis designed to test for an exposure-response relationship.

Testing for the existence of such a relationship provides a method of detecting whether an overall excess of deaths from a given cause is due to cadmium exposure or other confounding factors. We feel that the extra sensitivity gained by using this more complex procedure for assessing workers' exposure warrants the extra effort involved, despite the approximations necessary. Analyses based on simpler measures of exposure, such as duration of exposure, are of course also possible with our data and will be carried out.

Workers exposed only in more recent years, when assessments of exposure can be based on good environmental data, could in the future constitute a group within which an exposure-response relationship allowing for a more definite quantitative interpretation may be sought. In particular the existence of an effect due to low exposure to cadmium may be tested. The ongoing part of this study will enable such an analysis to be performed. More-detailed work histories could be ascertained for most of the workers in our study through extensive searching through records and verbal inquiries. For the whole population this procedure would, however, be extremely time-consuming and costly. If those workers in the population are selected who die of possibly relevant diseases, together with an adequate number of referents from the remaining population, a case-referent analysis based on more-detailed work histories becomes feasible. These improved work history data allow for a more sensitive test of possible mortality risks associated with cadmium exposure. It is our intention to collect the additional exposure data required and perform such an analysis.

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