

Cancer mortality among workers in a thermoelectric power plant

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CAMMARANO G, CROSIGNANI P, BERRINO F, BERRA G. Cancer mortality among workers in a thermoelectric power plant. *Scand J Work Environ Health* 10 (1984) 259–261. At a thermoelectric power plant in Turbigo (Milan, Italy), an analysis of the technological process has shown the presence of exposure to several carcinogens: polycyclic aromatic hydrocarbons, asbestos, hydrazine, polychlorinated biphenyls, chromium, nickel, and beryllium. An epidemiologic study was carried out to quantify the effect of the detected exposures on the workers, and the cancer mortality of the cohort was compared with the corresponding rates from the closest town and with cancer register data from a nearby province. Excess mortality was found for workers with 10 or more years of employment; the median latency time was about 20 years.

Key terms: carcinogens.

At a thermoelectric power plant in Turbigo (Milan, Italy) an analysis of the technological process has shown the presence of exposure to several carcinogens, ie, polycyclic aromatic hydrocarbons, asbestos, hydrazine, polychlorinated biphenyls, chromium, nickel, and beryllium (8).

The plant was established in 1928, and, after the technological upgrade which was made in 1956–1960, the power produced was raised from 35 MW to 145 MW in 1964 and up to 1,385 MW by 1970; from 1951 until now the fuel used has been petroleum naphtha, the present consumption of which is over 10⁶ t per year.

The technological process used at the plant can be summarized as follows: The water, previously deionized and degased, is sent into the pipe nest of the boiler, where it is heated by fuel oil combustion. The steam produced is superheated and moved to a turbine coaxial with an electric generator. The steam is then vacuum condensed, and the obtained water is used again.

The process can be considered to have been constant since 1951, except for the increase in power produced. Since 1968 however the fumes have not been extracted by fan units, but, instead, by positive pressure created in the boiler by forced air, and the fume exhaust is purely passive.

The objective of the present study was to quantify the effect of the exposure to the carcinogenic substances found in the thermoelectric power plant.

Material and methods

Exposure. Polycyclic aromatic hydrocarbons (2) are present in the fuel oil of the plant and are produced by oil combustion. Exposure is due to contact with fuel oil and with ashes periodically removed from boilers and to leakage of smoke into the work environment, due to the inside positive pressure in the boilers. In particular a fuel oil analysis, carried out by the Institute of Occupational Health of the University of Pavia, showed the presence of phenanthrene (64 µg/g), anthracene (5.4 µg/g), fluoranthrene (5.4 µg/g), pyrene (14.4 µg/g), benz(a)anthracene (7.1 µg/g), crysene + triphenylene (8.5 µg/g), benzo(a)pyrene (9.4 µg/g), benzo(e)pyrene (6.7 µg/g), and perylene (5.2 µg/g); 70 ppb of benzo(a)pyrene, 60 ppb of benzo(e)pyrene, and 50 ppb of perylene were also found in the boiler ashes. Air pollution from polycyclic aromatic hydrocarbons has not been directly measured, but high levels of sulfur dioxide (SO₂) and nitrous gases (5 mg/m³ or more for SO₂, measured by the Provincial Laboratory of Hygiene and Prophylaxis of Milano) have been frequently recorded, and they can be considered tracers of leakages from boilers with smoke containing polycyclic aromatic hydrocarbons.

Asbestos (amosite amphibole) (5) is used as insulating material for the turbines, boilers, and pipes and as protection against fire in the safety walls around the oil reservoirs. The workers are exposed during its periodic removal for maintenance.

Hydrazine (3), 15 % water solution, is used as a gas remover and against corrosion in the water-steam cycle. The workers are exposed to it during loading procedures. In 1981 a total amount of 25 t was used.

Polychlorinated biphenyls (6), mainly mixtures of hexa- and heptachlorobiphenyls with a presence of polychlorobenzene, is used as a dielectric in transformers and in pressure gauges. The workers are ex-

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posed in the course of some of the maintenance procedures and during refilling operations.

Chromium, nickel, and beryllium (4, 7) are present in the boiler ashes. The workers are exposed to these elements when the ashes are removed, a procedure which is done manually with hammers and picks. The content, measured by the aforementioned Institute of Occupational Health and the Central Laboratory of the National Board of Electricity, varies from traces to 1.35 weight % for chromium and from 0.18 to 13.22 weight % for nickel. A single determination of beryllium showed a concentration of 0.01 weight %.

Subjects. All of the 270 men who worked in the plant on 1 January 1960 or who were subsequently employed up to 31 December 1969 and who had worked in the plant for at least six months have been included in the study. The cohort has been completely traced up to 31 December 1980 with the use of company registers and census data from the municipalities in which the workers were born and resided. Twenty-six workers were found to have died.

Methods. The causes of death were ascertained from the death register of the municipality in which the death occurred. Whenever the quality of information was poor, an attempt was made to interview the next-of-kin and to trace clinical records.

The expected number of deaths in the cohort was computed with the person-year method using two cancer death rates, that of the Cancer Register of the Varese Province (Lombardy Cancer Registry), available for 1976–1977 (1), and that obtained from the death register of the Turbigo municipality (where most of the workers lived) for the period 1965–1979. The town of Turbigo is 5 km from the southern border of the Varese Province. Two reference populations were chosen because of the small number of Turbigo male inhabitants (3,225 in the 1971 census

survey), whereas the rates of the Lombardy Cancer Registry are computed for the 376,128 male residents.

The reference rates for nonneoplastic causes of death in the Varese Province in 1976–1977 were obtained from the National Institute of Health. They were based on official mortality data of the Italian Institute of Statistics.

Results

Fifteen cancer deaths were found for the workers during the study period. Table 1 shows the observed number of deaths by site and the corresponding expectancies based on the data from the Lombardy Cancer Registry. The overall standardized mortality ratio (SMR) for all cancer sites was 198 with 95 % confidence limits (CL), based on the Poisson distribution, of 111–326. The expected number of cancer deaths, based on the mortality rates of the Turbigo municipality, was 7.98, giving an SMR of 188.

As some of the carcinogens (asbestos, polycyclic aromatic hydrocarbons) were present in the general work environment too and most of the men frequently worked in different jobs, the only suitable indicator to quantify the exposure was its duration. When the cohort experience was separated into two groups, one with less than 10 years and the other with 10 or more years of exposure, and the person-years were computed for the latter after the exclusion of the first 10 years of employment (9), the excess risk appeared to be confined to the most exposed group only, the SMR being 276 in the comparison with the the Lombardy Cancer Registry data (95 % CL 143–482) and 260 in that with the Turbigo data. The less exposed group showed a cancer mortality similar to that of the general population, with 3 deaths observed versus 3.34 expected (3.35 for the Turbigo data).

The median time between the beginning of the exposure and cancer death was 19 years.

Table 1. Site-specific mortality experience of the cohort.

Cause of death (ICD-VIII ^a)	Site	Subjects with less than 10 years of exposure		Subjects with 10 years or more of exposure		All subjects	
		Observed	Expected ^b	Observed	Expected ^b	Observed	Expected ^b
140–209	All neoplasms	3	3.34	12	4.35	15	7.59
151	Stomach	1	0.43	2	0.61	3	1.05
161	Larynx	1	0.09	1	0.18	2	0.27
162	Lung	—	0.87	2	1.41	2	2.29
153	Colon	—	0.15	1	0.22	1	0.38
157	Pancreas	1	0.09	—	0.15	1	0.24
174	Breast	—	0.01	1	0.01	1	0.02
185	Prostate	—	0.05	1	0.15	1	0.20
188	Bladder	—	0.08	1	0.16	1	0.24
191	Brain	—	0.14	1	0.08	1	0.21
203	Myeloma	—	0.01	1	0.03	1	0.04
199	Unspecified	—	—	1	—	1	—
All nonneoplastic causes		1	16.01	10	16.53	11	32.54

^a International Classification of Diseases, eighth revision.

^b Determined from the death rates of the Lombardy Cancer Registry.

Discussion

The results show a two- to threefold excess for all-site cancer mortality among the long-term (over 10 years) employees of the thermoelectric power plant under study. Site-specific figures (table 1) do not allow the interpretation of the shown effect to be restricted to any particular organ. On the other hand, due to the presence of several carcinogens (each with several known or suspect target organs) and the small size of the cohort, the most significant indicator of the effect seems to be all-site cancer mortality.

The question might be raised of whether the observed difference between the actual and expected number of cases could be attributed to a better ascertainment of the causes of death in the cohort. In our study, examinations of clinical records and interviews of relatives led in a single case to the modification of the classification "not specified cause of death" to one of "neoplasm." In addition the mortality given by the Lombardy Cancer Registry is based on both death certificates and clinical records. It is therefore comparable with the procedure used to follow-up the studied cohort, and we can exclude the possibility that the shown excess might have been due to a differential ascertainment of the cause of death.

Smoking habits for the whole cohort were not available. They were known however for current employees in the plant. The current habits have been compared with those of a population sample drawn from an etiologic study conducted in the southern part of the Varese Province in 1980 (10). The age-adjusted comparison showed a higher proportion of nonsmokers (34 % observed versus 24 % expected) and a lower proportion of heavy (20 cigarettes or more per day) smokers (33 % observed versus 38 % expected) among the workers in the plant. It seems improbable therefore that the observed excess of cancer could have been due to differences in tobacco consumption.

The comparison of mortality for causes other than a neoplastic lesion was carried out with the use of the census mortality rates of the Varese Province; the expected number was 32.51 against the 11 observed deaths. This result could be attributed to the well-known lack of comparability of populations due to the "healthy worker effect" (11). As shown in table 1, the difference is particularly striking before 10 years of exposure has been reached, and it diminishes thereafter. Such a strong effect might be explained by the cohort's high median age (28.5 years) at the time of employment. As the cohort seems to be selected as particularly healthy, the estimated effect of exposure is probably lower than the true one, because the ex-

cess risk should be evaluated not only in a comparison with a nonexposed reference population but also with one with the same characteristics as the exposed one in respect to selection (11).

We conclude that the knowledge gained about the production process in the thermoelectric plant provides a number of indications of the need for preventive measures, both for existing and future plants. These measures appear to be a condition for the prevention of neoplasms.

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