

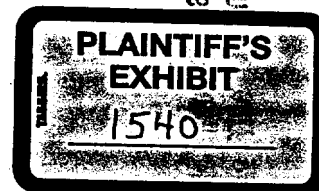
CANCER MORTALITY AMONG THREE SWEDISH MALE ACADEMIC COHORTS: CHEMISTS, ARCHITECTS, AND MINING ENGINEERS/METALLURGISTS

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INTRODUCTION, MATERIAL, AND METHODS

The mortality among chemists was first studied by Li *et al.* (1969).¹ They found an excess of mortality of malignant tumors, particularly lymphomas and pancreatic cancer. In our earlier publications (1976, 1978)^{2,3} an analysis was made of the mortality in two cohorts of males, who had graduated from two university schools of chemical engineering in Sweden between 1930 and 1950 and who were followed-up to the end of 1974. The mortality in this cohort was compared with that of the general Swedish male population. In the main, the results of this study were in accordance with the findings of Li *et al.*

For one of the two universities, the Royal Institute of Technology in Stockholm (Kungliga Tekniska Hogskolan, KTH), the study of the chemistry graduates has later been extended in several ways. The follow-up period has been prolonged and graduates from one more decade have been included. In regard to the expected death rates, we have estimated the expected number for the Swedish general working population instead of, as before, estimating the number for the whole general population. In order to achieve a social class standardization, with the intention of reducing both the "healthy worker" and the "survivor population" effects, as discussed by Fox and Collier (1977),⁴ we selected the male architects who had graduated from KTH in Stockholm during the years 1930-1959 as a control group. This architect-cohort had graduated from the same university, in the same city, during the same period of time. Thus, we had chosen an academic control group that probably had a similar background pattern, but which differed from the study population—the chemists—in terms of occupational chemical exposure during their years of education or later in the professional life. This part of the study has just been published.⁵

The study, however, has since then been extended to include one more cohort: namely, the male engineers who had graduated from the department of mining and metallurgy at KTH in Stockholm during the same period as the chemists and the architects. The hypothesis was that this group of engineers would, if studied, occupy an intermediate position between the chemists and the architects in terms of chemical exposure-related health damage because they hold an intermediate position in terms of exposure. This academic cohort, which will be referred to as the mining engineers, attended several courses of chemistry during their four-five years of education. Then, as professional men, some of them get into contact with chemical

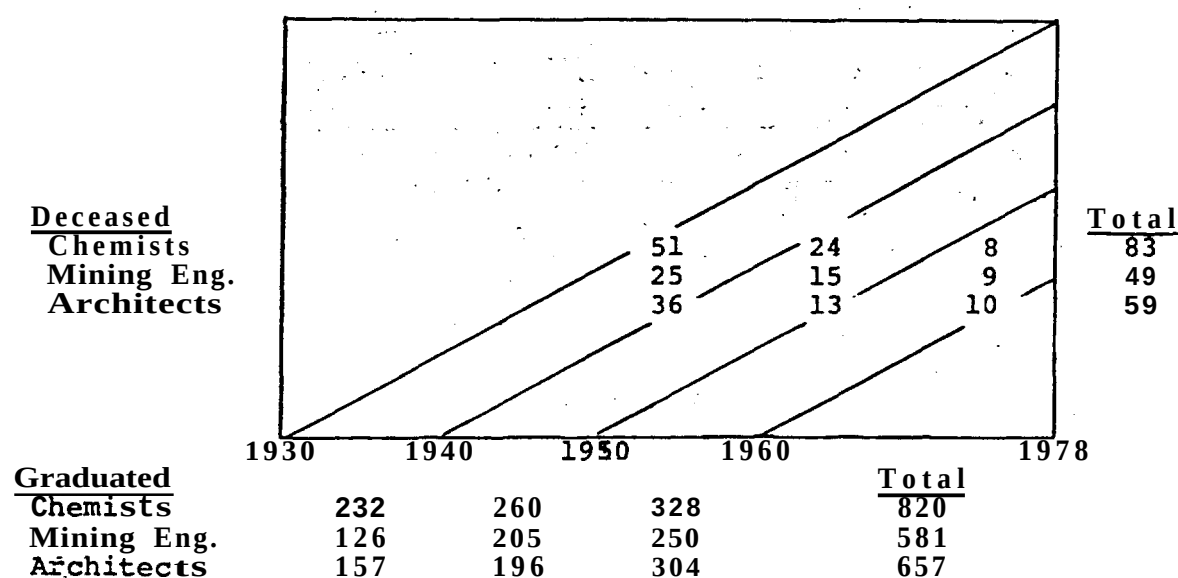


FIGURE 1. Number of graduated and deceased chemists, mining engineers/metallurgists, and architects by decade of graduation followed up to the end to 1977. (KTH, Royal Institute of Technology, Stockholm, Sweden.)

substances—organic or probably inorganic—that exist as occupational or environmental hazards in the mines or in various kinds of metal industries.

FIGURE 1 shows the size of the three cohorts and the number of participants from each decade: the 1930s, the 1940s, and the 1950s. The follow-up period ran to the end of 1977. Thus, the oldest individuals in the cohorts have had a follow-up period of just less than 50 years, measured from the year of graduation, while the youngest ones, the ones who graduated in 1959, have been followed-up for just less than 20 years.

The average graduation age was 26 years of age. The number of drop-outs in each cohort was low: 2 individuals each among the chemists and the architects and 3 among the mining engineers.

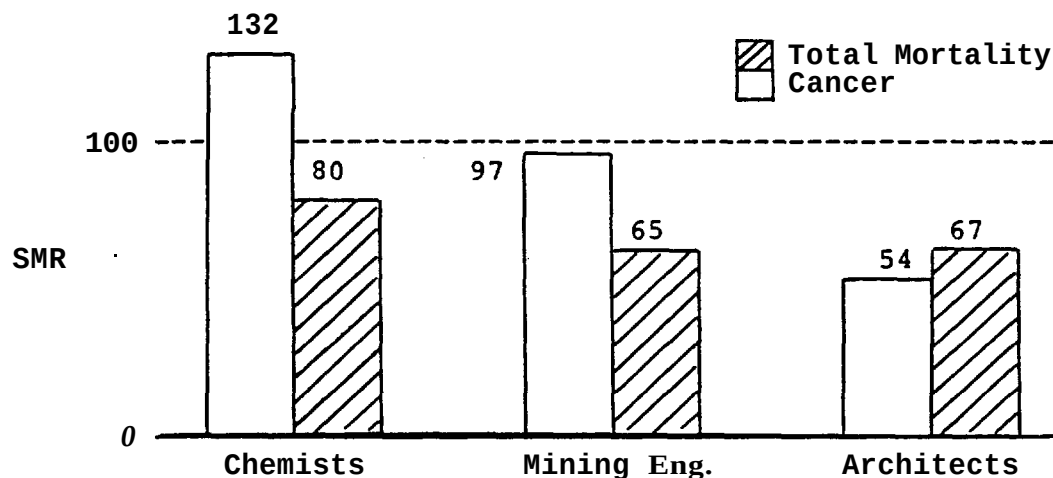
The statistical methods used in the comparison with the general working population and between the cohorts are described in detail in an earlier publication.⁵

RESULTS

FIGURE 2 shows the total mortality for the three cohorts. The standard mortality ratios (SMRs)—calculated in a comparison with the Swedish general male working population—are well below 100 for all three cohorts. When the relative risk is calculated, one can demonstrate that there is no significant difference between the total death rates in the three cohorts.

The figure shows that the neoplasm rate differs between the cohorts. The architects—the hypothetically unexposed group—have a low SMR for neoplasm deaths. However, the death rate due to neoplasms in this group is really very proportional since just below 20% of the total number of deaths in the architect cohort is due to neoplastic diseases.

The proportion of neoplastic deaths among the chemists is of quite another magnitude. The SMR goes well above 100. The proportion of neoplastic deaths among the mining engineers is also comparatively elevated. When the relative risk for neoplastic deaths is calculated, a significant increase can be demonstrated both



Cancer Mortality

Observed	32	17	11
Expected	24.2	17.5	20.5
P	0.11	0.45	0.04

Relative Risk (Compared to Architects)

RR	254	181
P	0.006	0.03

FIGURE 2 Cancer mortality (and total mortality) among KTH chemists, mining engineers/metallurgists, and architects compared with the Swedish general male working population and relative risks.

in the comparison between chemists and architects (2.5) and in the comparison between mining engineers and architects (1.8).

TABLE 1 contains the more interesting causes of death among the three cohorts. There is no excess of lung cancer among any of the cohorts, nor is there any obvious difference regarding this cause of death between the cohorts. In the comparison between the chemists and the architects, the difference in neoplastic mortality seems instead to be due to different rates of death among two other neoplastic code-groups, namely, the leukemia/lymphoma group—including three cases of Hodgkin's disease—and the glioma group. The table **also** shows a significant decrease in deaths due to circulatory diseases in all three cohorts.

DISCUSSION

The present paper is focused on the incidence of brain tumors since most of the results concerning the mortality pattern of two of the three KTH cohorts **has been** discussed in our earlier publications (1976, 1978, 1980).^{2, 3, 5} However, before turning to the main subject of this paper, some of the findings from **our most recent** part of the KTH cohort studies will be briefly commented upon, **as they are of interest**.

-The total **SMR** for all three male academic cohorts **are significantly lower in** comparison to the Swedish general male working population. **The main** explanation for these lowered **SMRs** is a significant **decrease in** deaths **due to** circulatory diseases. It is a well-known fact that academic professional groups have low **SMRs**. According to King (1970),⁶ the most privileged groups in this respect are the clergy-

TABLE 1

OBSERVED AND EXPECTED NUMBER OF DEATHS AMONG KTH CHEMISTS,
MINING ENGINEERS/METALLURGISTS, AND ARCHITECTS, EDUCATED
BETWEEN 1930 AND 1959, FOLLOWED UP TO DECEMBER 31, 1977

Cause of Death (ICD Code, 8th Rev.)	Chemists		Min./Metallurgists		Architects.	
	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.
All Causes	83	103.8*	49	74.9†	59	87.8†
All cancer (140-239)	32	24.2	17	17.5	11	20.5*
Digestive (150-159)	8	9.2	4	6.7	3	7.9*
Pancreatic (157)	2	1.6	0	1.1	2	1.4
Respiratory (160-163)	3	4.0	4	3.6	5	3.4
Prostatic (185-187)	3	1.5	0	1.1	1	1.4
Urinary (188-189)	3	1.8	2	1.2	0	1.5
Brain (191)	5	1.2†	2	0.9	1	1.0
Lymph./Hem. (200-209)	7	3.2*	2	2.3	0	2.7
Hodgkin (201)	3	0.7*	0	0.5	0	0.5
Circulatory (390-458)	22	40.4†	10	29.5†	20	35.1†
Accidents (E800-999)	15	21.9	16	15.5	15	17.6
Other causes	14	17.3	6	12.4*	13	14.6

* $0.01 < p \leq 0.05$.

† $0.001 < p \leq 0.01$.

man and the teachers. Doctors of medicine also have relative low SMRs, as shown in a recent Finnish study.⁷

As for cancer mortality, there is an increase in deaths due to this type of disease proceeding in a stepwise fashion from the architects to the mining engineers/metallurgists and then to the chemists. The lung cancer mortality incidence is not elevated among any of the three cohorts. And, in fact, it is not possible to demonstrate any single cause of cancer death that can explain the registered difference between mining engineers and architects. The limited number of total subjects in the two cohorts is one explanation for this shortcoming.

The comparison of the occurrence of neoplasms between the chemists and the architects yields a significant difference. This difference can mainly be explained by an increase of deaths among the chemists due to leukemias/lymphomas and to gliomas. The first of these groups has been commented upon in our earlier publications.^{3, 5}

The incidence of brain tumors is the subject for this meeting. Out of 32 neoplastic deaths among the chemists, we found that 5 were attributed to gliomas. Until recently, the literature was quite sparse about the etiology of this very malignant neoplasm. Experimental evidence has, however, shown that nitrosamides like methylnitrosourea (MNU) have a high ability to produce neurogenic tumors in animals.⁸ It was therefore interesting to discover that MNU was used routinely without special precautions in all educational programs involving a certain diazotization during the organic chemistry course. This substance was eliminated from use in the courses in Sweden during the middle of the sixties but this was not due to any awareness of possible health hazards. The reason was in fact purely practical, the substance was considered to be too reactive in its chemical properties. Obviously, this proposed association is so far just a theory. We are at present

conducting a case-control study with a view to finding possible etiological factors to gliomas.

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