SILICA DUST, RESPIRATORY DISEASE AND LUNG CANCER —RESULTS OF A PROSPECTIVE STUDY

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INTRODUCTION

Mineral particles are not generally considered to be carcinogenic, except for a few specific species such as asbestos, and the carcinogenicity of crystalline silica to humans has been a matter of controversy[2,4] since results of retrospective studies and results on persons selected for silicosis have been questioned.[6] Our investigation was initiated by the hypothesis that chronic irritation of the bronchial mucosa by inspirable particles increases lung cancer incidence. Meanwhile other and more detailed pathogenetic mechanisms have been discussed in this context, considering respiratory clearance, carrier effects and other combined effects.[2] Our contribution will be new results on the first cohort of dust exposed workers which has been followed prospectively from a preventive checkup in the 1950s, during the second part of life up to death (and in about 50% up to autopsy). Details of the source population,[10] setting up of cohorts[5] and first results of follow-up[8,9] have been given earlier.

METHODS

A mobile team of the occupational health care unit started screening examinations in 1950 which included an occupational and a smoking history.[10] All persons with a history of dust exposure were chest X-rayed and are the source of our exposed cohort. 1630 men given the first chest X-ray in 1950–1960 because of silica and/or heavy "inert" dust exposure were born before 1911 and resident in Vienna. An equal number of Viennese men without occupational dust exposure was selected from the occupational health care examination files by matching year of birth, year of first examination and smoking.[5] At a later control of exposure histories at the pension insurance board 5 men were found not to meet the eligibility criteria and were therefore eliminated from the study together with their matched counterparts (dustworkers: 1 because of confounding asbestos exposure, 1 because of lack of dust exposure, 1 because of being born 1911; references: 2 because of dust exposure). Thus we followed 1925 workers exposed to non fibrous dust in the metal, glass, ceramics, stone, construction, cleaning agent and a few other industries and 1625 non-dust-exposed workers from a great variety of branches (publishing and printing, chemical, construction, textile, leather, food, electrical industry, etc.).

Diagnoses at death were traced and encoded without knowledgement of the exposure. Death certificates in Vienna are based on autopsy in more than 50%,[3] but a small proportion of diagnoses had to be clarified with the reporting hospital or physician. The best available informations were used for comparison on dust and non-dust-exposed. The official diagnosis was used for comparison with the general population of Vienna, which gives conservative estimates of standard mortality ratios (SMR), because mortality (especially cancer mortality) is higher in Vienna than in Austria, and some of the cohort members moved to rural districts after retirement.

RESULTS

1621 dust-exposed (DUST) and 1621 reference subjects (NO DUST)=99,8% could be traced up to the end of 1986. 1442 DUST (89%) and 1384 (NO DUST) (85,4%) died. The underlying cause of death is given in Table I for 1439 (99,8%) DUST and 1379 (99,6%) NO DUST. Observed cases (0) in DUST divided by expected cases in NO DUST are given under Relative Risk (RR). This age-adjusted relative risk of DUST was significantly raised ($p < 0,001$, Poisson, two-sided) for lung cancer, stomach cancer, chronic obstructive lung disease (emphysema, bronchitis, asthma) and silicosis/fibrosis/tuberculosis of the lung. Gastrointestinal diseases (mainly liver cirrhosis) were found more frequent, too ($p < 0,05$).

Respiratory diseases were also found increased in OUST as secondary cause on death and additional diagnoses on death certificates (mainly silicosis and chronic obstuctive lung disease, but also pneumonias).

Table II shows official diagnoses of underlying cause of death and standard mortality ratios. In DUST overall mortality, lung cancer, stomach cancer, chronic obstructive lung disease, silicosis/fibrosis/tuberculosis and acute/infectious respiratory diseases was found higher ($p < 0,001$, Poisson, two-sided) than expected in Viennese men of same age. In NO DUST overall mortality was the same as in the general population; silicosis/fibrosis/tuberculosis, cardiovascular diseases and accidents were lower than expected and lung cancer was slightly higher ($p < 0,05$).

For 775 foundry workers, 475 grinders and other metal workers, 191 glass and ceramic workers, 87 stone cutters and construction workers and 65 other dust-exposed workers observed lung cancers and stomach cancers are given in Table III (32 workers could not be included in this stratification because the main branch of occupational dust exposure was

Table I
Main Causes of Death: Dust Exposed Compared to Reference Cohort

Best available diagnose	DUST 0	NO DUST 0	RR
cancer of lung	183	142	146***
" other respirat.o.	4	4	114
" stomach	80	48	190***
" intestine	37	50	88
" other digestive o.	50	45	125
" other sites	67	84	92
" not localised	1	2	
chron. obst. lung dis.	83	47	202***
tuberculosis, silicosis	78	15	513***
acut, infect. respir.d.	50	55	110
heart disease	362	404	106
cerebrovascular dis.	125	157	97
other vascular dis.	132	145	107
gastrointestinal dis.	93	84	127*
accidents, suicide	41	39	109
other disease	55	58	112
unknown, ill-defined	3	5	111

* $p < 0,05$, ** $p < 0,01$, *** $p < 0,001$

ill-defined on entry file). Table III shows increased lung cancer mortality in all subgroups of DUST with the highest SMR in stone and glass/ceramics ($p < 0,001$). The SMR for stomach cancer was above 100 in all strata, but significantly only in those employed in foundries and other metal industries.

Life table analyses showed reduced survival of DUST not before 7 years of observation and 58 years of age (Figure 1). At the median the survival difference between DUST and NO DUST was 3 years. Survival probability from lung cancer at age 70 was 91,4% in DUST (95% confidence interval: 89,9–92,9) and 71,7% in NO DUST (95% confidence interval: 93,2–95,6) which is significant (Figure 2).

DISCUSSION

In Viennese workers we found a relation between exposure to respirable particulates and mortality from lung cancer and chronic diseases of the lung. The rate of chronic obstructive lung deseases was 2-times higher and the rate of lung cancer was 1,5-times higher than in non-dust-exposed workers with comparable smoking habits. The 17% lung cancer increase in

Table II

Main Causes of Death: Dust Exposed and Reference Cohort Compared to General Population

OFFICIAL DIAGNOSE (ICD, 9.REV.)	DUST		NO DUST	
	O	SMR	O	SMR
CANCER OF LUNGS (162)	180	168***	142	117*
" OTHER RESPIRATORY O.(161, ETC.)	4	67	4	60
" STOMACH (151)	78	167***	47	89
" INTESTINE (152-154)	36	84	50	100
" OTHER DIGESTIVE (140-150, 155-159)	48	115	44	92
" OTHER	70	92	85	95
CHRON.OBSTR.LUNG DIS. (490-493)	77	205***	45	101
TUBERCULOSIS, SILICOSIS, FIBROSIS (011, 502, ETC.)	75	299***	17	63*
ACUTE, INFECT.RESPIRAT.D.(460-487)	52	135*	55	120
CARDIOVASCULAR D. (390-459)	628	97	707	92*
GASTROINTESTINAL D. (520-579)	95	109	85	87
ACCIDENTS, SUICIDE (800-999)	42	86	42	76*
ALL CAUSES	1442	123***	1384	100

+ $P<0,05$, ** $P<0,01$, *** $P<0,001$

Table III

Lung and Stomach Cancer in Dust Exposed Industries Compared to General Population

CANCER	FOUNDRY		METAL		GLASS/CERAMICS		STONE		OTHER	
DEATHS	O	SMR	O	SMR	O	SMR	O	SMR	O	SMR
LUNG	85	163***	44	135*	28	236***	15	293***	6	153
STOMACH	40	176***	21	149*	6	116	4	173	3	172

* $P<0.05$, ** $P<0.01$, *** $P<0.001$

non-dust-exposed workers compared to the general population could be due to smoking and occupational exposures (vapours etc.) except dust. In dust-exposed the increased lung cancer rate was found in all subgroups, which have very different confounding exposures (e.g. polycyclic aromatic hydrocarbons in foundries, possibly arsenic in glass industry, nitrosamines in some metal grinders, etc.). We discussed elsewhere[8,9] the minor importance of confounding exposures for our study, such as the very limited use of asbestos in Vienna and its metal industry (no signs of asbestos exposure were found on chest X-rays of dust-exposed and no mesotheliomas occurred), the lack of sources of radiation in the plants investigated (only in a few stone- and tunnelworkers radiation might have been a co-factor) and the negligible use of carcinogenic metals and compounds in iron foundries at the time of the cohort recruitment. Confounding exposures after registration seem to be of minor importance, too, because work histories obtained in 1982 from the national pension insurance board showed a low inter-industry and interplant mobility of dust-exposed (because of registration after age 40) and no second jobs with exposure to accepted carcinogens (one lung cancer case was exposed to glass wool as an insulator and a few other cases with suspected confounding exposure such as a sepiolite grinder are still alive or died from nonmalignant diseases).

Most earlier studies on lung cancer in dust workers have been biased by selection and competing causes of death (silicosis). In coal workers a protective effect of coal dust has been discussed.[7] The seemingly conflicting results on lung cancer in silica and "inert" dust-exposures could perhaps be explained by a multistage model of carcinogenesis: Genotoxic substances (from tobacco smoke as well as from foundry air or other sources) could function as initiators and particles as adsorbens and promotors. In this case it would not be surprising if lung cancer increases with total dust load and not necessarily e.g. with PAH-concentrations, even though both might be involved. From available measurements in our study[8] we cannot decide whether silica or total respirable or inspirable dust was responsible for the increase of lung cancer, but we suspect that also "inert" dust exposure (if heavy and long lasting) can promote chronic obstuctive lung diseases and lung cancer. Bombardment of airways by dust particles, even "inert" ones, could eventually sustain high levels of polymorphonuclear recruitment, alveolar macrophage activation and finally result in a disturbed balance of protease and antiprotease activity.[1]

From the age in which we observed excess lung cancer deaths (Figure 2) we conclude that screening examinations should be continued after retirement from a job with heavy dust exposure. Screening for chronic obstructive lung disease must begin much earlier. Most important, however, is primary prevention by reduction of dust exposures, even "inert" ones.

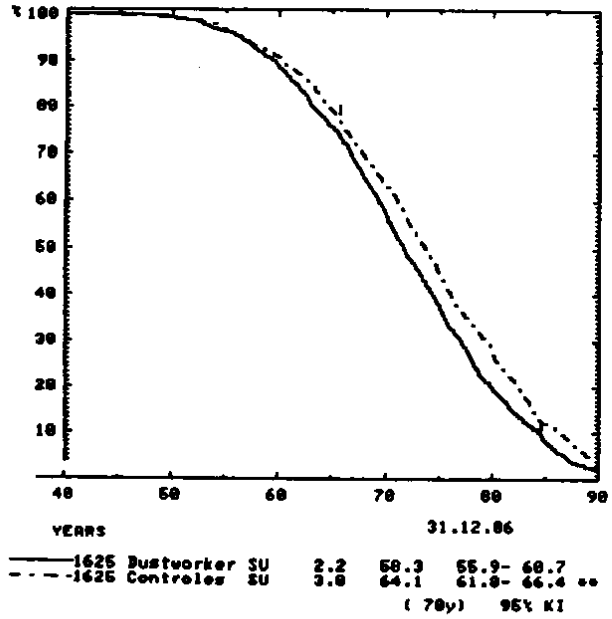

Figure 1. Survival of dust-exposed (solid line) and reference subjects (dashed line).

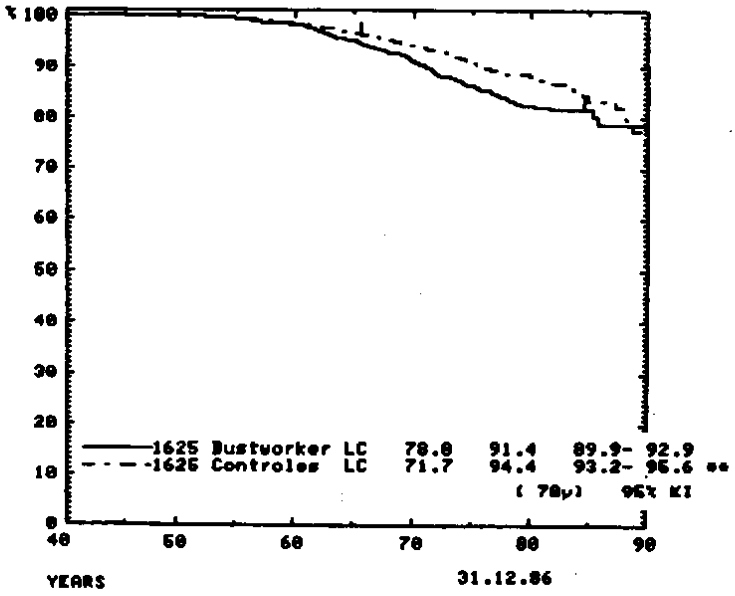

Figure 2. Survival from lung cancer (dust-exposed: solid line, reference subjects: dashed line).

SUMMARY

From 1625 men examined in 1950–1960 with a history of occupational exposure to silica and other non-fibrous particulates in foundries, other metal, glass, ceramic, brick, stone and some other dusty industries 1621 were traced up to 1986, 1442 died, 183 from lung cancer (SMR 168), 80 from stomach cancer (SMR 167), 83 from chronic obstructive lung disease (SMR 205) and 78 from silicosis/fibrosis /tuberculosis (SMR 299).

From 1625 non-dust-exposed workers from the same source population, matched in 1950–1960 to dust exposed workers for age, smoking and begin of observation, 1621 were traced, 1384 died, 142 from lung cancer (SMR 117), 48 from stomach cancer (SMR 89), 47 from chronic obstuctive lung disease (SMR 101) and 15 from tuberculosis/fibrosis (SMR

63). Life table estimates show that primary and secondary prevention should not be focused on pneumoconioses alone.

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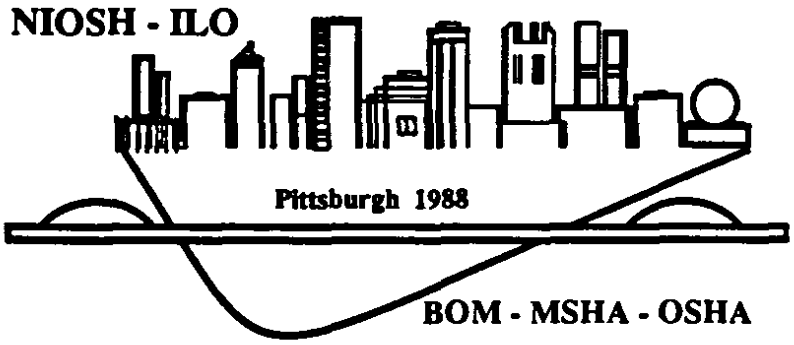

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