CANCER MORTALITY AMONG WORKERS EXPOSED TO CUTTING-OIL MIST

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INTRODUCTION

A large body of evidence has accumulated since the latter half of the nineteenth century describing carcinogenic effects for the skin associated with intense and prolonged exposure to various types of mineral oil. Initial observations, coming from Scotland and the European continent, dealt with the so-called "paraffin cancers" occurring in workers engaged in the refining of shale oil, coal oil, and petroleum.[1, 2] Subsequently, extensive surveys of men working as mule spinners in the cotton textile industry in England demonstrated the high incidence of scrotal cancer resulting from intimate and continued bodily contact with "spindle" oils used to lubricate the machines.[3]

More recently, there has been an increasing awareness of serious skin problems associated with exposure to lubricating and cooling fluids during the processes of cutting and grinding metals. Reports of epitheliomas of the hands, arms, and scrotum among machine tool operators originated in England, where ad hoc studies and a mandatory notification system uncovered the problem.[4, 5] Observations of skin cancer in machine operators employed at a Canadian plant were followed by a series of animal experiments which revealed that a soluble cutting fluid as used in industry was carcinogenic to three different strains of mice when applied to the skin.[6, 7]

Much less is known about possible health effects resulting from the inhalation of mineral-oil mists. Although it was recognized that cotton mule spinners were exposed to airborne concentrations of the lubricating oil, there have been no reports of unusual respiratory cancer patterns in these workers. Today, a major source of exposure to oil mists occurs in machining operations necessitating the use of cutting oils as coolants and lubricants. These processes result in widespread dissemination of oil mists and vapors caused by the violent action of tool on workpiece.

MATERIALS AND METHODS

The present study refers to 5,189 white males who were employed at a particular plant at some time between 1938 and 1967 and who worked in metal machining jobs there for at least one year. The group was followed for mortality from January 1, 1938 to December 31, 1967, utilizing information from company records, the Internal Revenue Service, and the Social Security Administration. Death certificates were recovered for 901 known decedents and the underlying cause of death was classified according to the 7th Revision of the ICD by a trained nosologist. A degree of noncomparability is introduced in some of the

cause-specific mortality comparisons during the period 1938–47, when the 5th Revision of the ICD was in effect for national mortality data. However, less than 20% of the observed deaths and person-years within the study group occurred in that time period and hence, the overall results should not be seriously affected. Moreover, coding of deaths involving cancer, which are the main concern of the present study, was not changed substantially from the 5th to 7th revisions of the ICD.

Cause-specific mortality rates for the total U.S. white male population were used to compute expected numbers of deaths for the study group. The expected numbers were calculated by applying United States rates specific for age and calendar year to the corresponding set of person-years at risk of dying within the study group. Both observed and expected deaths were tabulated simultaneously by duration of employment in metal machining jobs and time since first employment in such jobs. Relative differences between observed and expected numbers are shown as Standardized Mortality Ratios (SMR). The Poisson distribution was used for testing statistical significance when observed deaths were less than fifty, and a simple one degree of freedom chi-square test was employed when observed deaths exceeded fifty.

Vital status at the close of observation was still unresolved for approximately two percent of the study group. These persons were treated as alive in the analyses. Fifty-eight persons reported as having died by the Social Security Administration but for whom a death certificate could not be located readily are included in the "all causes" mortality figures but were not allocated to any of the specific cause categories. Through an oversight, 23 deaths occurring overseas during World War II were included in the results. In one instance, these deaths caused an overstatement of mortality rates large enough to bias the results. This case is pointed out in the description of the results.

Results

Table 1 presents the comparative mortality experience of the 5,189 men with at least one year employment at metal machining jobs. Total mortality was nine percent less than expected—a result not very surprising when contrasting death rates in a working population with those for the general population. Respiratory and digestive cancer were the only major cause categories for which the numbers of deaths in the study group were not too different from expectation. Even the class of violent deaths (which includes accidents, homicides, and suicides) shows a significant deficit in observed deaths.

In Table 2, results are subdivided according to attained age for the total group. The apparent excess in total mortality for the "under 45" age group is due entirely to the inadvertent inclusion of 23 war deaths occurring during World War II in the results. When these are deleted, a five percent deficit in "all causes" mortality is seen for this age group. The residual category is similarly affected, and the revised SMR for this class becomes 76. Except for possibly two of the major cancer categories, disease risks appear not to differ greatly by age. The genearally favorable mortality experience seen for the total group even carries over to the nonworking years. The only disease categories that indicate any tendency toward an excess are respiratory cancer and cancer of sites other than the respiratory or digestive system.

In Table 3, mortality in the study group is analyzed according to the interval

TABLE 1

OBSERVED AND EXPECTED DEATHS AND STANDARDIZED MORTALITY RATIOS BY CAUSE *

Cause of Death	Obs.	Exp.	SMR
All causes	959	1050.9	91 †
All cancer	150	158.1	95
Digestive	58	60.3	96
Respiratory	46	46.3	99
Other	46	51.5	89
Stroke	59	77.1	77 ‡
Heart disease	374	437.8	85 †
Respiratory disease	41	48.0	85
Violence	85	121.8	70 †
Residual	192	208.0	92

* White male production workers with at least one year employment in metal machining jobs.
† SMR significantly different from 100 at .01 level.
‡ SMR significantly different from 100 at .05 level.

of time from first employment in metal machining jobs. As expected, the most substantial deficits in mortality occurred during the first 20 years following employment in metal machining jobs. However, even after 30 years have elapsed since first employment, mortality from most major causes is not excessive. The only exceptions of note are the 41% increase in digestive cancer (18 observed vs. 12.8 expected) and the 15% excess in respiratory cancer (11 observed vs. 9.6 expected), although both results are statistically nonsignificant.

Further examination of respiratory cancer mortality patterns in the study group is shown in TABLE 4. Results are presented according to duration of

TABLE 2

OBSERVED AND EXPECTED DEATHS AND STANDARDIZED MORTALITY RATIOS BY CAUSE AND ATTAINED AGE *

	< 45			45–64			≥ 65		
Cause of Death	Obs.	Exp.	SMR	Obs.	Exp.	SMR	Obs.	Exp.	SMR
All causes	196	181.5	108	425	508.3	84 †	338	361.0	94
All cancer	19	16.0	119	68	84.0	81	63	58.0	109
Digestive	4	5.2	77	31	31.6	98	23	23.5	98
Respiratory	6	3.8	158	23	27.8	83	17	14.7	116
Other	9	7.0	129	14	24.7	57 ‡	23	19.8	116
Stroke	2	5.3	38	19	30.2	63 ‡	38	41.5	92
Heart disease	44	42.7	103	183	225.0	81 †	147	170.1	86
Respiratory disease	7	6.6	106	21	21.1	100	13	20.2	64
Violence	43	63.3	68 ‡	35	45.9	76	7	12.6	56
Residual	59	47.5	124	86	102.0	84	47	58.4	80

* White male production workers with at least one year employment in metal machining jobs.
† SMR significantly different from 100 at .01 level.
‡ SMR significantly different from 100 at .05 level.

employment and interval from first employment in metal machining jobs. The data do not suggest any kind of exposure-response relationship or latency effect, although the numbers of observed deaths become quite small in many of the cells. The greatest share of the respiratory cancer mortality (in terms of absolute numbers of observed and expected deaths) is contributed by the men with less than five years employment. Even within this subgroup there is no gradient in risk with increasing latency.

TABLE 5 portrays mortality patterns for digestive cancer in the same manner as those just seen for respiratory cancer. Again there is no strong indication of a definite exposure-response relationship in the data. The only category exhibiting an excess of any real magnitude is that for men employed between 10 and 14 years at metal machining jobs, where there were 9 observed deaths vs. 5.1 expected.

TABLE 3

OBSERVED AND EXPECTED DEATHS AND STANDARDIZED MORTALITY RATIOS BY CAUSE AND INTERVAL FROM ONSET OF EXPOSURE *

	1–19 Years			20–29 Years			≥ 30 Years		
Cause of Death	Obs.	Exp.	SMR	Obs.	Exp.	SMR	Obs.	Exp.	SMR
All causes	477	525.7	91 †	303	326.5	93	179	198.7	90
All cancer	68	72.4	94	45	52.6	86	37	33.1	112
Digestive	29	28.4	102	11	19.1	58	18	12.8	141
Respiratory	19	19.9	95	16	16.8	95	11	9.6	115
Other	20	24.1	83	18	16.7	108	8	10.7	75
Stroke	17	32.5	52 ‡	21	24.9	84	21	19.6	107
Heart disease	157	199.6	79 ‡	140	145.0	97	77	93.2	83
Respiratory disease	21	21.4	98	17	16.0	106	3	10.6	28 †
Violence	58	85.3	68 ‡	23	27.5	84	4	9.0	44
Residual	117	114.4	102	47	60.4	78	28	33.2	84

* White male production workers with at least one year employment in metal machining jobs.

† SMR significantly different from 100 at .05 level.

‡ SMR significantly different from 100 at .01 level.

DISCUSSION

In basing all of the preceding comparisons on the general U.S. population, we recognized that the expected numbers of deaths were being overstated for several disease categories, especially the chronic degenerative conditions that progress slowly (e.g. heart disease). For cancer (and respiratory cancer, in particular), however, past experience has shown that general population mortality figures do not seem to bias the results seriously. Hence, we felt that the cancer experience of this working population could be validly assessed by reference to national data as the basis for comparison.

Admittedly, we were somewhat surprised at the findings for respiratory cancer. Prior evidence seemed to suggest that at least certain cutting oils (e.g. the insoluble or "neat" oils) could produce skin cancer in exposed workers. There was also indirect evidence that respiratory cancer was associated with

TABLE 4

ND EXPECTED DEATHS FROM RESPIRATORY CANCER AND STANDARDIZED MORTALITY RATIOS BY DURATION OF AND INTERVAL FROM ONSET OF EXPOSURE *

			Interval From Onset of Exposure							
	Total		1–19 Years			20–29 Years			≥ 30	
Obs.	Exp.	SMR	Obs.	Exp.	SMR	Obs.	Exp.	SMR	Obs.	Ex
46	46.3	99	19	19.9	95	16	16.8	95	11	9.
30	30.5	98	17	16.4	104	11	12.4	89	2	1.
4	5.5	73	2	1.9	—	2	1.7	—	0	1.
5	3.8	132	0	1.2	—	1	1.1	—	4	1.
7	6.5	109	0	0.4	—	2	1.6	—	5	4.

le production workers with at least one year of employment in metal machining jobs. SMR not shown wh ected deaths are less than 5.

TABLE 5

ND EXPECTED DEATHS FROM DIGESTIVE CANCER AND STANDARDIZED MORTALITY RATIOS BY DURATION OF AND INTERVAL FROM ONSET OF EXPOSURE *

			Interval From Onset of Exposure							
	Total		1–19 Years			20–29 Years			≥ 30	
Obs.	Exp.	SMR	Obs.	Exp.	SMR	Obs.	Exp.	SMR	Obs.	Ex
58	60.3	96	29	28.4	102	11	19.1	58	18	12.
32	38.2	84	20	23.4	85	8	12.7	63	4	2.
8	7.5	107	4	2.8	— †	1	2.3	—	3	2.
9	5.1	176	5	1.5	333 ‡	—	1.6	—	4	2.
9	9.5	95	0	0.6	—	2	2.4	—	7	6.

le production workers with at least one year of employment in metal machining jobs.
hown when both observed and expected deaths are less than 5.
ficantly different from 100 at .05 level.

exposure to mineral-oil mist from Waterhouse's observations of increased incidence of respiratory cancer among men who had already developed scrotal cancer as a result of mineral-oil exposure.[8]

Insoluble, soluble, and synthetic cutting fluids have all been used at one time or another in the plant covered by the present study. However, in compiling work histories, no attempt was made to associate each machining job with the specific kind of cutting fluid in use at the time. Consequently, we have no idea what proportion of the population had exposure to insoluble cutting oils as opposed to those who never had these exposures. Our feelings are that the vast majority of workers had mixed exposures. If, however, there was an increased risk of respiratory cancer associated with only one kind of cutting fluid, and if sufficient numbers of persons were exposed to it, we would expect the overall rate of respiratory cancer to be elevated.

The excess mortality for digestive cancer following 30 years from onset of exposure was slightly greater than that for respiratory cancer but still not striking or statistically significant. These cancers also were found to be higher than expected in Waterhouse's follow-up of scrotal cancer cases, most of which were probably due to occupational exposure to mineral oil. For this presentation, it was not possible to examine death rates for cancers of specific digestive organs; however, these will be investigated in future analyses.

It is also our intention to examine other cancer sites in detail, especially the genitourinary organs, leukemia, and lymphomas. On this issue it might be noteworthy to recall that Henry and the Kennaways found bladder cancer to be almost twice the expected rate among "cotton spinners and piecers" during the period 1921–28.[9] This group included the mule spinners who had substantial exposure to mineral oil mist. The Kennaways later reported a substantial deficit in lung cancer for this group during the same period.[10]

Data from three American mortality studies of occupational exposure to oil mists would suggest that the work environment is not associated with unusual cancer experience.[11-13] However, it should be noted that all of these reports were based on limited data and hence do not represent conclusive findings.

To date, evidence of carcinogenic effects in animals from inhalation of mineral-oil mists has not been found.[14, 15] At relatively low levels, no significant pulmonary lesions were found in mice, rats, and rabbits, but monkeys experienced a greatly increased incidence of focal pneumonia and interstitial inflammation. However, it is indicated that at very high concentrations over extended time periods, progressive pulmonary fibrosis could be expected to occur.

There were no deaths in the study group from scrotal cancer. Two deaths were charged to skin cancer (not melanoma). One of these was a squamous-cell carcinoma on the face and the other was a squamous-cell carcinoma on the leg. I present this information for the sake of completeness, since we did not expect to gain any meaningful insight into skin cancer problems in this group from mortality data alone. An inquiry to the medical department of the plant revealed no knowledge of an unusual frequency of skin cancers in oil-exposed workers.

In the presence of results such as the ones presented here for respiratory cancer, it is perhaps important to recall several points concerning cutaneous cancer associated with occupational exposure to mineral oil. First, a very low incidence of skin cancer has prevailed among English wool mule spinners in contrast to the experience of cotton mule spinners, even though the same kind

of oil was used in both processes. Various factors that might have accounted for this phenomenon have been discussed, such as differences in spindle speed, oiling frequency, ambient temperatures in the workroom, and the presence of animal oils in the raw wool.[16] Second, Kipling, in reporting on the scrotal cancer experience of toolsetters in the Birmingham region, states that no cases have occurred in the great majority of engineering works in that area.[17] Finally, there appears to be a clustering of oil-related skin cancer in the Arve region of France, where there are many small metal machining "shops" in which poor quality oil is reportedly used.[18] No evidence of unusual skin cancer patterns has yet come to light from other regions in France. All of the above observations suggest that the relationship between human cancers and mineral oil is not a simple one, but is affected by a variety of factors.

Conclusions

In conclusion, we see no unusual mortality from respiratory cancer among men engaged in metal machining jobs in the present study. Even mortality from digestive cancer is not so different from expectation as to indicate any serious health problems. However, an assessment of cancer mortality for specific digestive sites is needed before final conclusions are drawn.

I think we can say that whatever potential hazards these oils might have possessed, there was at least no overwhelming impact on the respiratory and digestive cancer experience of persons exposed to them under the conditions of work prevalent in this particular plant. We still might want to consider whether the present results can be generalized to all industrial processes where mineral-oil mists are prevalent.

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References

1. Scott, A. 1922. On the occupation cancer of the paraffin and oil workers of the Scottish shale industry. Br. Med. J. **2**: 1108–1109.
2. Kennaway, E. L. 1925. The anatomical distribution of the occupational cancers. J. Ind. Hyg. **7**: 69–73.
3. Southam, A. H. & S. R. Wilson. 1922. Cancer of the scrotum: The etiology, clinical features, and treatment of the disease. Br. Med. J. **2**: 971–973.

4. CRUICKSHANK, C. N. D. & J. R. SQUIRE. 1950. Skin cancer in the engineering industry from the use of mineral oil. Br. J. Ind. Med. **7:** 1–11.
5. CRUICKSHANK, C. N. D. & A. GOUREVITCH. 1952. Skin cancer of the hand and forearm. Br. J. Ind. Med. **9:** 74–79.
6. MASTROMATTEO, E. 1955. Cutting oil and squamous-cell carcinoma. Part I. Incidence in a plant with a report of six cases. Br. J. Ind. Med. **12:** 240–243.
7. GILMAN, J. P. W. & S. D. VESSELINOVITCH. 1955. Cutting oils and squamous-cell carcinoma. Part II. An experimental study of the carcinogenicity of two types of cutting oils. Br. J. Ind. Med. **12:** 244–248.
8. WATERHOUSE, J. A. H. 1971. Cutting oils and cancer. Ann. Occ. Hyg. **14:** 161–170.
9. HENRY, S. A., N. M. KENNAWAY & E. L. KENNAWAY. 1931. The incidence of cancer of the bladder and prostate in certain occupations. J. Hyg. **31:** 125–137.
10. KENNAWAY, E. L. & N. M. KENNAWAY. 1947. A further study of the incidence of cancer of the lung and larynx. Br. J. Cancer **1:** 260–298.
11. GOLDSTEIN, D. H., J. N. BENOIT & H. A. TYROLER. 1970. An epidemiologic study of an oil mist exposure. Arch. Environ. Health **21:** 600–603.
12. PASTERNACK, B. & L. EHRLICH. 1972. Occupational exposure to an oil mist atmosphere. Arch. Environ. Health **25:** 286–294.
13. ELY, T. S., S. F. PEDLEY, F. T. HEARNE & W. T. STILLE. 1970. A study of mortality, symptoms, and respiratory function in humans occupationally exposed to oil mist. J. Occ. Med. **12:** 253–261.
14. LUSHBAUGH, C. C., J. W. GREEN & C. R. REDEMANN. 1960. Effects of prolonged inhalation of oil fogs on experimental animals. Arch. Ind. Hyg. Occ. Med. **1:** 237–247.
15. WAGNER, W. D., P. G. WRIGHT & H. E. STOKINGER. 1964. Inhalation toxicology of oil mists. I. Chronic effects of white mineral oil. Amer. Ind. Hyg. Assoc. J. **25:** 158–168.
16. LEE, W. R. & J. K. MCCANN. 1967. Mule-spinners' cancer and the wool industry. Br. J. Indus. Med. **24:** 148–151.
17. KIPLING, M. D. 1968. Oil and the skin. *In* Annual Report of HM Chief Inspector of Factories, 1967. Chapter IV. HM Stationery Office. London, England.
18. KIPLING, M. D. 1971. Oil cancer in the Savoy Alps and the Birmingham region: A comparison. Trans. Soc. Occ. Med. **21:** 73–78.