

CANCER RISK AMONG RUBBER WORKERS

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Studies of the cancer risk among rubber workers published since 1968 are reviewed. The total material examined comprised 80,000 workers and 4000 cancer deaths. An increased risk of stomach cancer, lung cancer, bladder cancer, and leukemia was found. The increased risk of cancer at a specific anatomic site was correlated with the mode of exposure specific for the working area or division. On the other hand, no clear exposure-risk relationship could be demonstrated. It is likely that there has been an increased risk of cancer since the elimination of α - and β -naphthylamine by 1950. However, the etiologic fraction is less than that due to prevalent exposures increasing the risk of common cancers at specific anatomic sites.

INTRODUCTION

The rubber industry is a typical example of the chemical industries. Epidemiologic evidence for an increased cancer risk in the rubber industry was reported by the British Registrar General in 1934; an estimate of 10% was given for the excess risk of total deaths (General Register Office, 1934). This increased risk was attributed to cancer. The U.S. Department of Health, Education, and Welfare (1961-1963) reported an 8% excess of cancer deaths in male rubber workers dying in 1950. In their classical epidemiologic study, Case and Hosker (1954) investigated bladder cancer as an occupational disease in the rubber industry in England and Wales. The assumed carcinogen, β -naphthylamine, was largely eliminated from the production process by 1950.

MATERIAL USED

In this paper we review more recent studies. Few reports were published in the late 1950s and early 1960s; the years of publication of the reports reviewed here range from 1968 to 1979. By restricting the discussion to relatively recent data, we attempted to examine present exposures within the rubber industry. However, some of the material originates from the 1940s, and the results may exaggerate the cancer risks in the rubber industry in the last few years. Nevertheless, there is a long latent period between the first carcinogenic exposure and the diagnosis of cancer, preventing the use of very recent data only.

The studies reviewed here originate from England, the United States, and Finland. The published reports are partly based on the same material. We have selected studies so that the same results are covered in this review only once. Altogether, 12 studies were accepted after this process of selection (Andjelkovich et al., 1976, 1977; British Rubber Manufacturer's Association, 1976; Fox and Collier, 1976; Fox et al., 1974; Kilpikari, 1979; McMichael et al., 1974, 1976a, 1976b; Manson and Nakano, 1976a, 1976b; Monson and Fine, 1978) (Fig. 1); the total material was covered by six of these (Table 1). The total material comprised

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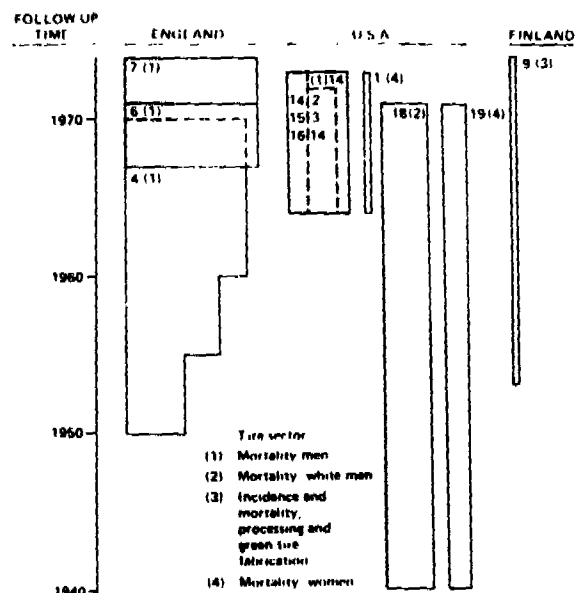


FIGURE 1. Diagram of the materials reviewed. The numbers refer to individual studies: (1) Andjelkovich et al. (1978); (2) Andjelkovich et al. (1976); (3) Andjelkovich et al. (1977); (4) BRMA (1976); (6) Fox and Collier (1976); (7) Fox et al. (1974); (9) Kilpikari (1979); (14) McMichael et al. (1976a); (15) McMichael et al. (1976b); (16) McMichael et al. (1974); (18) Monson and Nakano (1976a); (19) Monson and Nakano (1976b).

73,433 male and 7533 female rubber workers. Males only were included in a more detailed study. The time of follow-up ranged from 1940 to 1974 and the length of follow-up from 4 to 30 yr.

As a rule, the results were reported in terms of the observed and expected numbers of deaths transformed into standardized mortality ratios (SMRs). The total number of deaths

TABLE 1. Standardized Mortality Ratios for All Deaths and All Cancers among Male Rubber Workers in Different Studies

Study	SMR		Size of cohort	Years of follow-up
	All deaths	All cancers		
Fox and Collier, 1976	97	115	40,867	1 ^a
Fox et al., 1974	102	111	40,867	3
BRMA, 1976	88	98	37,221	20
McMichael et al., 1976a	94	100	18,903	9
Monson and Nakano, 1976a	88	94	13,571	31
Kilpikari, 1979	70	100	1,331	22
Total	90	97	73,433	

^aFor the total SMR.

among males was 12,786, 3156 of which were due to cancer. The number of cancer deaths among females was 1114.

The observed and expected numbers of deaths in these 12 studies were pooled, and SMRs for the total material by determinants of risk are reported here. Consequently, the SMRs are age-study-adjusted mortality rates by the indirect method. The observed numbers are reported in the tables together with the SMRs. The total number of deaths is not equal to the sum of the deaths in individual categories because in some of the studies the results were not reported in each of the subclassification used in this review.

RESULTS

The SMR for the total material and for all causes of death was 90, which probably indicates a slight bias in the selection into work and in survival in the industry. In other words, the healthy worker effect in the total material is likely to be about 10%. The total risk of cancer deaths was very close to that expected ($SMR = 97$), which indicates a lesser bias for factors related to cancer risk or an excess risk of cancer. The difference between the SMRs for all causes and for cancers is close to the 10% reported in 1934 for the period 1929-1931 by the British Registrar General (General Register Office, 1934).

There were differences in the risk of death between the anatomic sites of cancer (Table 2). The SMRs for bladder cancer, stomach cancer, and leukemias were between 110 and 120, whereas the risk of brain tumors was only 70% of that expected. The only statistically significant difference was, in fact, the reduced risk of tumors of the central nervous system. The biological significance of this result is questionable, however, because of the multitude

TABLE 2. Standardized Mortality Ratios and Numbers of Deaths due to Site-specific Cancer among 80,966 Rubber Workers^a

ICD no. ^b	Primary site	Male		Female	
		SMR	No.	SMR	No.
140-239	All neoplasms	110	762		
140-209	Malignant neoplasms	97	3156	88	299
150-159	Digestive organs and peritoneum	98	364	88	86
150-151	Stomach	114	425	155	4
150-153	Large intestine	105	267	137	11
150-154	Rectum	91	115	203	4
160-163	Respiratory organs				
160-162	Trachea, bronchus, and lung	102	1403	122	24
174	Breast			76	57
180-189	Genitourinary organs			107	39
180-180	Cervix uteri			84	2
180-185	Prostate	102	204		
180-188	Bladder	117	154	196	9
191-192	Central nervous system	69	66	102	8
200-203	Lymphatic system	101	51	121	18
204-207	Leukemia	116	148	97	9

^aThe data were obtained from following studies: Andjelkovich et al. (1977, 1978); British Rubber Manufacturer's Association (1976); Fox and Collier (1976); Fox et al. (1974); McMichael et al. (1976a, 1976b); Monson and Nakano (1976a).

^bInternational Classification of Diseases, 8th rev.

of statistical tests carried out and because of the potential effects of selection. The risk of cancer among female rubber workers was essentially the same as that among males (Table 2).

The small excess risk in the selected primary sites should be correlated with the length of exposure. The original studies do not permit a mutually exclusive classification by length of exposure. Instead, we estimated the risk for those exposed for more than 1, 5, 10, and 25 yr (Table 3).

Only for stomach cancer was there an exposure-risk relationship. However, the different basic materials and lack of data for stomach cancer in workers with more than 25 yr of exposure may invalidate the comparability of the figures, even if the mortality was greater than expected for stomach cancer, lung cancer, bladder cancer, and leukemias.

Indirect evidence for an exposure-risk relationship was provided by the classification of the subjects according to the year when the employee started work (Table 4). No differences were found, consistent with the hypothesis of an association between length of exposure and overall risk of cancer or risk of cancer at selected anatomic sites. On the contrary, there was a consistently increasing risk of cancer death with the year when the subject started work. The increased risk during recent years may be an indication of greater reliability of the basic material rather than of an increase in carcinogenic exposure with time. There was an SMR of 238 for bladder cancer for the cohort starting work in 1940-1949 and a decrease for the more recent cohorts.

Processing was the only division with a significantly increased risk of cancer (Table 5). In only one research project (Fox et al., 1974; Fox and Collier, 1976) was the risk of cancer reported for sectors of the rubber industry. The tire sector, however, was considered in four studies (Table 6), with data specified according to division and to risk of cancer by anatomic site. In the total tire sector there was a considerably increased risk of stomach cancer (SMR = 145) and leukemia (SMR = 129).

Mode of exposure varies between the different divisions within the tire sector. Processing workers are exposed through gastrointestinal and respiratory organs by inhaling and ingesting dust, while building workers are exposed through the skin by handling the rubber. Curing workers are mainly exposed to hot vapors, and this is likely to affect them through the respiratory organs. Increased chemical exposure of Finnish rubber workers in all the divisions was confirmed by Vainio et al. (1978), who found an increase in urinary thioethers in workers in all these divisions. The mode of exposure should be correlated with the anatomic site of the cancer.

A classification of the data within the tire sector by division (Table 7) revealed that processing workers also had a high risk of cancer. High risks were found for stomach (SMR = 184) and bladder (SMR = 166) cancers and for leukemia (SMR = 137).

Similarly, high risks of leukemia, respiratory cancer, and stomach cancer were found within the curing sector. Because the numbers were small, only the increased risk of respiratory cancer (SMR = 149) was statistically significant. The effects of exposure through the skin among building workers might result in an increased number of skin cancer cases. Skin cancer patients have high survival rates and few deaths from skin cancer are likely, even with an increased risk. The small number of cases results in a large random error, which may prevent reliable conclusions.

There have been only two studies of cancer incidence among rubber workers. The one reported from the United States (Monson and Fine, 1978) derived the new cases of cancer from hospital-based cancer registries; the only population-based cancer registry material was from Finland (Kilpikari et al., 1979). In the U.S. study, an SMR of 650 was reported for skin cancer among rubber workers in the tire assembly division. No cases of skin cancer were found in the Finnish material. The results by anatomic site of cancer are largely in accordance with the mode of exposure.

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TABLE 3. Standardized Mortality Ratios and Numbers of Deaths by Length of Exposure and Cause of Death in Male Rubber Workers

Length of exposure (yr)	Study	All deaths		All cancers		Stomach		Lung		Bladder		Leukemia	
		SMR	No.	SMR	No.	SMR	No.	SMR	No.	SMR	No.	SMR	No.
>1	Fox and Collier, 1976	102	2018	111	592	102	59	118	281	195	37	128	14
>5	BRMA, 1976	82	5079	97	1955	114	233	106	698	119	62	105	82
	Monson and Nakano, 1976a												
>10	BRMA, 1976	94	5106	100	1650	143	171	103	555	103	48	101	64
	McMichael et al., 1976a												
>25	Monson and Nakano, 1976a	86	2890	98	576	NA ^a	NA	165	20	129	31	162	37

^aNot available.

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TABLE 4. Standardized Mortality Ratios and Numbers of All Deaths and Deaths from Site-specific Cancers by Year Employee Started Working in Rubber Industry^a

Year employee started working	All deaths		All cancers		Lung		Bladder		Leukemia	
	SMR	No.	SMR	No.	SMR	No.	SMR	No.	SMR	No.
1925	86	2040	92	349	130	8	140	24	140	21
1925-1934	80	1740	100	378	200	14	140	19	160	25
1940-1949	103	485	104	133	117	67	239	11	NA ^b	NA
1950-1959	102	622	105	174	120	88	175	10	107	16 ^c
1960-1966	106	497	122	153	128	74	166	7	NA	NA

^aThe data were obtained from the following studies: BRMA (1976); Fox and Collier (1976); Monson and Fine (1978).

^bNot available.

^c1951-1960.

TABLE 5. Standardized Mortality Ratios and Numbers of Cancer Deaths among Male Rubber Workers by Division^a

Division	SMR	No.
Processing	118	285
Product fabrication	96	764
Curing	101	105
Product finishing	106	304
Chemical production	82	28
Services	95	645

^aThe data were obtained from the following studies: Andjelkovich et al. (1977); BRMA (1976); Fox and Collier (1976); Monson and Nakano (1976a).

TABLE 6. Standardized Mortality Ratios and Numbers of Deaths due to Site-specific Cancers among Male Tire Workers^a

ICD no.	Primary site	SMR	No.
140-239	All neoplasms	107	1533
151	Stomach	145	145
162	Lung	104	520
188	Bladder	112	61
191	Brain	90	28
204-207	Leukemia	129	57

^aThe data were obtained from the following studies: Fox (1976); Fox et al. (1974); McMichael et al. (1976b); Monson and Nakano (1976a).

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TABLE 7. Standardized Mortality Ratios and Numbers of Deaths due to Site-specific Cancers among Male Tire Workers by Division^a

Division	Stomach		Respiratory		Bladder		Leukemia		All neoplasms	
	SMR	No.	SMR	No.	SMR	No.	SMR	No.	SMR	No.
Processing	184	26	110	12	166	2	137	23	120	60
Building	103	11	56	13	135	17	122	25	85	70
Curing	140	7	149	64	75	1	270	5	101	66

^aThe figures are based on the following studies: Andjelkovich et al. (1977); Fox and Collier (1976); Fox and al. (1974); McMichael et al. (1974); Monson and Fine (1978); Monson and Nakano (1976a).

The total cancer risk among rubber workers in the studies published in the 1970s was not essentially different from that expected on the basis of the normal mortality of the total population that included the exposed cohort. There was an increased risk for two primary sites—stomach and bladder and for leukemias. A high risk of cancer at a specific anatomic site was likely to be correlated with mode of exposure; i.e., with the working division. The SMRs for the selected cancers varied between 140 and 180 among the high-risk groups by working area. Even within these high-risk groups, the relative risks were less than 2 when based on sufficient numbers of cases, indicating a relatively small etiologic fraction due to exposure. For several of the leading primary sites of cancer there are common risk factors with bigger relative risks. The relative risk of lung cancer due to smoking is about 10, that of breast cancer due to factors related to fertility is about 3, and that of stomach cancer related to nutrition or standard of living is more than 2.

However, occupational exposures can often be prevented, and we do not wish to neglect the problem. Furthermore, epidemiologic studies of occupational exposure are subject to bias due to the healthy worker effect, and it is difficult to find reliable data on the exposed cohort and on cancer deaths. These biases can lead to underestimates of the true effects of exposure.

On the basis of the most recent epidemiologic studies of cancer risk among rubber workers, we conclude that the risk is increased. However, only in exceptional circumstances is the excess risk of the same magnitude as that for the leading cancers and common exposures.

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