Cancer incidence and mortality among Swedish leather tanners

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Abstract

***Objectives*—The aim was to study the incidence of cancer among Swedish leather tanners.**

***Methods*—A cohort of 2026 subjects who had been employed for at least one year between 1900 and 1989 in three Swedish leather tanneries, was established. The cancer incidence and mortality patterns were assessed for the periods 1958–89 and 1952–89 respectively, and cause-specific standardised incidence and mortality ratios (SIRs and SMRs) were calculated.**

***Results*—A significantly increased incidence of soft tissue sarcomas (SIR 4·27, 95% confidence interval (95% CI) 1·39–9·97) was found, based on five cases. Excesses, (not statistically significant) was also found for multiple myelomas (SIR 2·54, 95% CI 0·93–5·53), and sinonasal cancer (SIR 3·77, 95% CI 0·46–13·6).**

***Conclusions*—The increased incidence of soft tissue sarcomas adds support to previous findings of an excess mortality in this diagnosis among leather tanners. A plausible cause is exposure to chlorophenols, which had occurred in all three plants. The excess of multiple myelomas may also be associated with exposure to chlorophenol. The association between incidence of cancer and specific chemical exposure will be elucidated in a cohort-based case-referent study.**

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Keywords: leather tanners; multiple myeloma; soft tissue sarcoma.

Many chemicals are handled in leather tanning and processing. Some of them are carcinogens or suspected carcinogens—for example, hexavalent chromium salts, vegetable tannins, chlorophenols, aniline dyes, formaldehyde, methylmercury, arsenic, benzene, and chlorinated organic solvents.[1]

It is well established that exposure to leather dust, especially in the shoe and boot industry, has caused increased risks for nasal cancer,[2] but it is not clear whether tanning and leather processing also increase such a risk. Some results, although far from conclusive, indicate a possible association.[3 4]

An association between tanning and lung cancer has been reported,[5–7] but was not found in other studies.[3 8 9] Slight and non-significant increased risks for bladder cancer were found among workers in tanning and leather processing plants,[10 11] but not in all studies.[9 12 13] An excess of mortality in soft tissue sarcomas among leather tanners has been indicated in two previous cohort studies,[3 14] but this was based only on one and two incident cases. In previous Swedish studies an increased risk for pancreatic cancer[8] and renal cancer,[15] was found, and a cluster of testicular cancer among workers in leather finishing departments has been reported.[16 17]

Due to the inconsistent epidemiological results, the International Agency for Research on Cancer has not yet found it possible to conclude whether leather tanning and processing is associated with any excess risk of cancer.[18] A likely explanation for the varying results of the epidemiological studies is that the chemical exposures have differed between the plants. It must therefore be of importance to elucidate whether specific chemical exposures in the tanning and finishing processes may be associated with risk of cancer.

The aim of the present study was to investigate the cancer incidence in a cohort of workers from three Swedish leather tanneries. The cohort can also serve as a study base for a case-referent study that will allow a more detailed analysis with respect to associations between specific chemical exposures and specific tumours.

Materials and methods

PRODUCTION AND EXPOSURE

Plant A was run between 1906 and 1988, manufacturing coloured nappa (full grain) leather, mainly for shoes (uppers). Chromium compounds dominated in the tanning processes, but a minor department at the factory produced leather tanned by vegetable dyes for book binding until the late 1960s. Arsenic sulphides were used in the liming and hair removing procedure until about 1950. Up to about 1960, mercury compounds may have been used for the preservation of the stored raw hides; later only sodium chloride was used. During the 1940s, methylmercury was added to the soaking and tanning baths to prevent the development of mould in damp leather stored at the factory, and in semi-manufactured products (bovine hide split) for export. From about 1950, methylmercury was replaced by chlorophenols, which were in use until 1980. Azo dyes were widely used for deep colouring of leather during the entire production period. Black dyes, based on

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benzidine, were used until 1980. Pigments containing azo dyes were also used for surface colouring at the finishing department. Formaldehyde solutions (5–10% v/v) were extensively used for curing water soluble casein based surface coatings. These coatings were gradually replaced by organic solvent based nitrocellulose coatings, which were introduced in the late 1920s. Formaldehyde curing casein coatings were practically out of use after the mid 1970s. The use of organic solvents in the finishing department was at a maximum during the 1970s. The coatings based on organic solvents were partly replaced by water dispersed nitrocellulose, acrylate, or uretane polymers. During the last years, the proportions between solvent and water based coatings were about equal. The organic solvents used were mainly butyl acetate, cyclohexanone, ethanol, ethyl acetate, ethylene glycol, methylethyl ketone, methylisobutyl ketone, toluene, and xylene. Benzene was a frequent contaminant of technical toluene up to the mid-1960s.

Plant B was run between 1897 and 1989, manufacturing nappa and suede leather for gloves and garments. For tanning, vegetable tannins, formaldehyde, aluminium, and chromium compounds were used. Formaldehyde tanning involved extensive exposure to formaldehyde, but was done on a limited scale and practically disappeared after 1965. Chromium tanning was introduced in about 1930. Arsenic compounds were probably used as preservatives of the imported, raw skins. Arsenic sulphides were used in the liming procedure until the early 1950s. Methylmercury compounds were used as preservatives probably from the early 1940s until the beginning of the 1960s. They were replaced by chlorophenols, which were used until 1980 and then again in the second half of the 1980s. About 50% of the skins were degreased through extraction with organic solvents. The earliest degreasing agent was petrol, which probably contained benzene. It was replaced by trichloroethylene (during the 1950s and 1960s) and 1,1,1-trichloroethane (during the 1970s and 1980s). During the 1980s perchloroethylene was occasionally used. The degreasing operation involved considerable solvent exposure for some process operators. Judged from the earliest available data on the excretion of trichloroacetic acid in urine, these workers were exposed to daily average air concentrations of trichloroethylene in the range of 50–200 ppm in 1964. From the beginning of the 1980s, the exposure to degreasing agents was considerably reduced through technical measures. Most of the skins were deeply coloured with azo and benzidine dyes. Formaldehyde curing caseine coatings were in use until 1975. In the early 1950s, water dispersed polymer coatings were introduced and totally replaced the solvent based coatings from the late 1960s.

Plant C was run in the same premises from 1860 until it closed down in 1991. Until 1960, the dominating product was sole leather treated with vegetable tannins. These were extracts from quebracho (South America), mimosa (South Africa), chestnut (Italy), and domestic oak and pine. Extracts from the mangrove tree were used for dyeing. A small production of leather tanned with chrome alum started in the 1940s. During the first half of the 1960s, the main production changed from sole leather to chrome tanned, coloured nappa for shoes (uppers), suitcases, and leather gifts. Methylmercury was used as a fungicide in the tanning process until about the mid-1950s. It was replaced by chlorophenols, which were in use until 1979. Dyes derived from azo compounds and benzidine were extensively used for the chrome tanned, soft leather. The use of such dyes increased during the last years due to customer demand for leather coloured throughout. The large increase in the production of soft leather led, from the beginning of the 1960s, to a corresponding increase in the use of surface coatings, and thus to an increased consumption of organic solvents. The products used were similar to those used in plant A, although a larger proportion of the coatings were water based.

COHORT

Name, date of birth, address, and dates of start and end of employment were obtained for the blue collar workers through each of the three company records. For plant A, the company record comprised subjects employed from 1917 onwards, but was not considered as complete and valid until 1966. The corresponding calendar-years for plant B were 1900 and 1930, and for plant C 1902 and 1946.

For 92 workers the Swedish 10 digit personal identification code could not be retrieved, and they were thus excluded from the cohort. Another 51 subjects were excluded as they had died or emigrated before the start of the observation periods, and 10 subjects were excluded because they were 80 or older at the start of the observation periods. The remaining 3613 workers had been employed for at least one day before 1987. Of those, 2031 who had been employed for at least one year before 1987, 482 were women and 1549 were men. Vital status was determined on December 31 1989 (table 1). Only five subjects (0·2%) were lost to follow up. The final cohort thus comprised 2026 subjects, providing 42 548 person-years under risk. The average duration of employment in the cohort was 12·7 years, the average first year of exposure was 1955, and the average duration of follow up was 21·7 years.

Table 1 Vital status as of 31 December 1989 among workers employed for at least one year in three Swedish leather tanneries

Tannery	*Living in Sweden*	*Dead*	*Emigrated*	*Lost to follow up*	*Total*
A	418	52	7	0	477
B	681	233	9	3	927
C	427	189	8	2	627
All	1526	474	24	5	2031

Table 2 Mortality 1952–89 in 2060 subjects employed for at least one year, by time since first exposure

		Years since first exposure											
		1–10				> 10				Total			
Cause of death	ICD-8	O	E	SMR	(95% CI)	O	E	SMR	(95% CI)	O	E	SMR	(95% CI)
Malignant tumours	140–209	53	48·4	1·10	(0·83–1·44)	66	60·6	1·09	(0·85–1·39)	119	109	1·09	(0·91–1·31)
Cardiovascular diseases	390–458	77	75·4	1·02	(0·81–1·28)	117	119	0·99	(0·82–1·18)	194	194	1·00	(0·87–1·15)
Ischemic heart diseases	410–414	44	51·3	0·86	(0·63–1·16)	84	81·1	1·03	(0·83–1·29)	128	132	0·97	(0·81–1·15)
Respiratory diseases	460–519	6	8·5	0·71	(0·26–1·54)	12	13·1	0·92	(0·47–1·60)	18	21·6	0·83	(0·50–1·34)
Asthma, bronchitis, emphysema	490–493	4	3·4	1·18	(0·32–3·03)	2	4·8	0·42	(0·05–1·50)	6	8·2	0·73	(0·27–1·59)
Accidents, poisonings, and violence	800–999	29	21·7	1·34	(0·91–1·94)	18	17·5	1·03	(0·62–1·65)	47	39·2	1·20	(0·89–1·60)
All causes	000–999	183	172	1·06	(0·92–1·23)	237	234	1·01	(0·89–1·15)	420	406	1·04	(0·94–1·14)

O = Observed number of deaths; E = expected number of deaths; SMR = standardised mortality ratio.

INFORMATION ON CAUSES OF DEATH AND TUMOURS

Information on cause of death (1952–89) was obtained from Statistics Sweden. The death certificates were coded according to the International Classification of Diseases (ICD). These codes were transformed to the 8th revision of the ICD (ICD-8). Information on tumours (coded according to the ICD, 7th revision (ICD-7)) diagnosed from 1958 to 1989, was obtained from the National Swedish Tumour Registry.

RISK ESTIMATES

Expected mortality for the period 1952–89 was calculated from calendar–year, cause, sex, and five year age group specific mortalities for each of the two counties where the plants had been located. These were obtained from Statistics Sweden. Date of death, emigration, or a persons 80th birthday were used as individual end points, whichever occurred first. Similarly, yearly incidence rates for cancer in the period 1958–89 were obtained from the National Swedish Tumour Registry, from calendar-year, sex, and five year age group specific incidence rates for each of the two counties. Date of death, tumour diagnosis, emigration, or a persons 80th birthday were used as individual end points, whichever occurred first. Cause specific standardised mortality/incidence ratios (SMRs/SIRs) and 95% confidence intervals (95% CIs) were calculated according to the Poisson distribution, or to the χ^2 distribution if the expected values were greater than 10.

Table 3 Cancer incidence 1958–1989 in 2026 subjects employed for at least one year and in 1417 subjects when a 20 year induction-latency period was used

		No induction-latency period				⩾ 20 years induction-latency period			
Site	ICD-7	O	E	SIR	(95% CI)	O	E	SIR	(95% CI)
Lip	140	5	2·5	1·98	(0·64–4·63)	5	2·0	2·45	(0·80–5·72)
Oral cavity	141, 143, 144	2	1·7	1·20	(0·15–4·35)	2	1·4	1·43	(0·17–5·16)
Pharynx	145–148	2	1·3	1·55	(0·19–5·60)	1	1·0	0·97	(0·02–5·41)
Oesophagus	150	4	2·3	1·76	(0·48–4·51)	3	2·0	1·53	(0·32–4·47)
Stomach	151	9	11·5	0·78	(0·36–1·48)	8	10·0	0·83	(0·36–1·63)
Colon	153	16	15·1	1·06	(0·62–1·75)	14	13·0	1·08	(0·59–1·81)
Rectum	154	12	11·2	1·07	(0·55–1·87)	11	9·5	1·16	(0·58–2·07)
Pancreas	157	9	6·0	1·51	(0·69–2·86)	8	5·2	1·55	(0·67–3·05)
Nasal cavities	160	2	0·5	3·77	(0·46–13·6)	1	0·4	2·44	(0·06–13·6)
Larynx	161	1	2·0	0·51	(0·01–2·83)	0	1·7	0.00	(0·00–2·24)
Lung	162·1	20	16·6	1·21	(0·75–1·88)	19	14·3	1·33	(0·82–2·11)
Breast	170	20	15·4	1·30	(0·81–2·04)	19	12·9	1·47	(0·90–2·33)
Cervix	171	5	3·0	1·67	(0·54–3·89)	3	2·1	1.42	(0·29–4·14)
Corpus	172, 174	3	4·0	0·74	(0·15–2·18)	1	3·4	0·30	(0·01–1·64)
Ovary	175	6	4·0	1·49	(0·55–3·24)	5	3·4	1·47	(0·48–3·44)
Prostate	177	32	25·0	1·28	(0·89–1·82)	29	22·2	1·31	(0·89–1·90)
Testis	178	2	1·2	1·68	(0·20–6·07)	1	0·5	2.00	(0·05–11·1)
Kidney	1800	6	6·1	0·98	(0·36–2·14)	5	5·1	0.97	(0·32–2·27)
Urinary bladder	180·1, 181	14	13·1	1·07	(0·59–1·80)	14	11·2	1·25	(0·68–2·09)
Malignant melanoma	190	5	6·6	0·76	(0·25–1·78)	5	5·0	1·00	(0·33–2·34)
Skin	191	8	6·7	1·19	(0·51–2·35)	7	5·9	1·19	(0·48–2·44)
Nervous system	193	8	7·4	1·09	(0·47–2·14)	5	5·6	0·89	(0·29–2·08)
Thyroid gland	194	1	1·4	0·70	(0·02–3·90)	1	1·0	1·05	(0·03–5·86)
Endocrine glands	195	4	2·5	1·58	(0·43–4·05)	4	1·9	2·06	(0·56–5·28)
Soft tissue sarcomas	197	5	1·6	3·18	(1·03–7·43)	5	1·2	4·27	(1·39–9·97)
Non-Hodgkin's lymphoma	200, 202	4	5·7	0·70	(0·19–1·78)	3	4·7	0·64	(0·13–1·87)
Hodgkin's lymphoma	201	0	1·4	0·00	(0·00–2·56)	0	0·8	0·00	(0·00–4·44)
Multiple myeloma	203	6	2·8	2·17	(0·79–4·71)	6	2·4	2·54	(0·93–5·53)
Leukaemias	204–207	5	6·0	0·84	(0·27–1·95)	5	4·5	1·12	(0·36–2–61)
Acute leukaemia	204·0, 205·0, 206·0, 207·0	1	2·1	0·47	(0·01–2·63)	1	1·7	0·57	(0.01–3·20)
Chronic lymphatic leukaemia	204·1	2	2·1	0·97	(0·12–3·51)	2	1·7	1·15	(0·14–4·15)
All sites	140–209	233	200	1·16	(1·02–1·32)	204	167	1·22	(1·06–1·40)

O = Observed number of cases; E = expected number of cases; SIR = standardised incidence ration.

Table 4 Cancer incidence 1958–89 in 1417 subjects employed for at least one year, with a 20 year minimum induction latency period

		Plant A				*Plant B*				*Plant C*			
Tumour site	*ICD-7*	*O*	*E*	*SIR*	*(95% CI)*	*O*	*E*	*SIR*	*(95% CI)*	*O*	*E*	*SIR*	*(95% CI)*
Lip	140	0	0·2	0·00	(0·00–17·1)	2	1·0	1·94	(0·24–7·02)	3	0·8	3·81	(0·79–11·1)
Stomach	151	0	0·9	0·00	(0·00–4·09)	6	5·5	1·09	(0·40–2·37)	2	3·3	0·61	(0·07–2·21)
Pancreas	157	1	0·6	1·61	(0·04–8·95)	5	3·7	1·36	(0·44–3·18)	3	1·7	1·77	(0·37–5·18)
Lung	162·1	1	1·3	0·75	(0·02–4·17)	14	9·0	1·55	(0·85–2·61)	4	3·9	1·02	(0·28–2·62)
Breast	170	0	0·4	0·00	(0·00–10·6)	18	12·4	1·45	(0·88–2·33)	1	0·2	6·06	(0·15–33·8)
Prostate	177	2	2·7	0·75	(0·09–2·70)	13	11·3	1·15	(0·61–1·96)	14	8·2	1·71	(0·94–2·87)
Kidney	180·0	0	0·5	0·00	(0·00–7·05)	3	3·1	0·96	(0·20–2·81)	2	1·5	1·33	(0·16–4·81)
Urinary bladder	180·1,181	1	1·1	0·92	(0·02–5·11)	10	6·9	1·45	(0·70–2·67)	3	3·3	0·97	(0·20–2·84)
Soft tissue sarcoma	197	0	0·1	0·00	(0·00–33·3)	2	0·8	2·60	(0·32–9·40)	3	0·3	10·5	(2·16–30·6)
Myeloma	203	1	0·3	3·88	(0·10–21·6)	3	1·3	2·25	(0·46–6·56)	2	0·8	2·63	(0·32–9·51)
All	140–209	17	14·6	1·16	(0·69–1·89)	127	110	1·15	(0·96–1·38)	60	42·8	1·40	(1·08–1·81)

O = Observed number of cases; E = expected number of cases; SIR = standardised incidence ratio.

Table 5 Standardised incidence ratios (SIRs) for some tumours with respect to of duration of employment and calender year for start of employment: the first 20 years since start of employment were exluded from the observation period

		Duration of employment											
	Start of employment	*1–10*				*> 10*				*Total*			
Tumour	*(calendar-year)*	*O*	*E*	*SIR*	*(95% CI)*	*O*	*E*	*SIR*	*(95% CI)*	*O*	*E*	*SIR*	*(95% CI)*
Lung cancer:													
	<1950	6	4·3	1·38	(0·51–3·02)	11	8·1	1·35	(0·67–2·42)	17	12	1·36	(0·81–2·22)
	⩾1950	1	1·1	0·90	(0·02–5·02)	1	0·7	1·35	(0·03–7·53)	2	1·9	1·08	(0·13–3·91)
	All	7	5·4	1·29	(0·52–2·65)	12	8·9	1·35	(0·70–2·36)	19	14	1·33	(0·82–2·10)
Prostate cancer:													
	<1950	3	5·2	0·58	(0·12–1·69)	21	14	1·47	(0·93–2·84)	24	19	1.23	(0·80–1·86)
	⩾1950	3	1·6	1·91	(0·39–5·58)	2	1·2	1·72	(0·21–6·23)	5	2·7	1·83	(0·59–.4·27)
	All	6	6·8	0·89	(0·33–1·93)	23	15·4	1·49	(0·96–2·27)	29	22·2	1·31	(0·88–1·90)
Soft tissue sarcomas:													
	<1950	1	0·4	2·33	(0·06–13·0)	3	0·6	5·26	(1·09–15·4)	4	1·0	4·00	(1·09–10·2)
	⩾1950	1	0·1	10·0	(0·25–55·7)	0	0·1	0·00	(0·00–52·7)	1	0·2	5·88	(0·15–32·8)
	All	2	0·5	3·77	(0·46–13·6)	3	0·6	4·69	(0·97–13·7)	5	1·2	4·27	(1·39–10·0)
Myelomas:													
	<1950	3	0·8	3·90	(0·80–11·4)	3	1·3	2·29	(0·47–6·69)	6	2·1	2·88	(1·06–6·28)
	⩾1950	0	0·2	0·00	(0·00–21·7)	0	0·1	0·00	(0·00–33·5)	0	0·3	0·00	(0·00–13·2)
	All	3	0·9	3·19	(0·66–9·33)	3	1·4	2·11	(0·44–6·17)	6	2·4	2·54	(0·93–5·53)
All malignant tumours:													
	<1950	62	58	1·07	(0·82–1·37)	117	88	1·33	(1·10–1·60)	179	146	1·22	(1·05–1·42)
	⩾1950	15	13	1·19	(0·67–1·96)	10	8·6	1·16	(0·56–2·13)	25	21	1·18	(0·77–1·76)
	All	77	70	1·09	(0·86–1·37)	127	97	1·31	(1·10–1·57)	204	167	1·21	(1·06–1·40)

Results

MORTALITY

The overall mortality in the cohort did not differ from that expected (420 deaths observed *v* 406 expected, SMR 1·04, 95% CI 0·94–1·14; table 2). This was true for deaths from malignant tumours (SMR 1·09) and cardiovascular disease (SMR 1·00). Time since first exposure did not affect these risk estimates.

INCIDENCE OF CANCER

The overall incidence of cancer was slightly, but significantly, enhanced (233 cases *v* 200 expected, SIR 1·16, 95% CI 1·02–1·32; table 3). When the first 20 years since the start of employment was excluded from the observation period, the SIR increased to 1·22. All five cases of soft tissue sarcoma and all six cases of multiple myeloma had been diagnosed at least 20 years since the start of employment (SIR 4·27, 95% CI 1·39–9·97; and SIR 2·54, 95% CI 0·93–5·53 respectively; table 3). The risk estimates were above unity and increased slightly with a 20 year induction latency period, also for other diagnoses; breast cancer (SIR 1·47, 95% CI 0·90–2·33), prostate cancer (SIR 1·31, 95% CI 0·89–1·90), pancreatic cancer (SIR 1·55, 95% CI 0·67–3·05), lung cancer (SIR 1·33, 95% CI 0·82–2·11), bladder cancer (SIR 1·25, 95% CI 0·68–2·09), and lip cancer (SIR 2·45, 95% CI 0·80–5·72). Two cases of sinonasal cancer (one squamous cell carcinoma and one adenocarcinoma) occurred (SIR 3·77, 95% CI 0·46–13·6), but only one of them had been diagnosed more than 20 years after the start of employment.

With a 20 year induction latency period, the overall incidence of cancer was significantly increased in plant C (SIR 1·40, 95% CI 1·08–1·81; table 4). The risk estimates for plant A (SIR 1·16) and plant B (SIR 1·15) were not significantly increased. Three of the cases of soft tissue sarcoma had been employed in plant C (SIR 10·5, 95% CI 2·16–30·6), and two in plant B (SIR 2·60, 95% CI 0·39–9·40). The increased incidence of cancer in plant C was also partly due to an increased risk for lip cancer (SIR 3·81, 95% CI 0·79–11·1) and prostate cancer (SIR 1·71, 95% CI 0·94–2·87). As very few women had been employed in plants A and C, the risk estimate for breast cancer was almost solely based on plant B (SIR 1·45). The incidence of myelomas was equally distributed between the plants.

Workers employed for at least 10 years had a higher overall incidence of cancer (SIR 1·31, 95% CI 1·10–1·57) than those employed for a shorter period (SIR 1·09, 95% CI 0·86–1·37; table 5). There was also a tentative association between duration of employment and risk for prostate cancer, but not for lung cancer. No obvious associations were seen with soft tissue

sarcoma or myelomas, but the numbers were too few to allow a valid interpretation. Whether the workers had been employed before 1950 or not did not affect the SIRs.

Discussion

The main result of the study was the significant fourfold increase in risk for soft tissue sarcoma. As all five cases were diagnosed at least 20 years after the start of employment, it is probable that the finding is real. The excess of multiple myelomas was not statistically significant, but still noteworthy.

The occurrence of a healthy worker selection into employment has often been found among industrial workers and may distort the results of a cohort study. This phenomenon is characterised typically by a low overall mortality, and occurs because healthy persons are likely to gain employment.[19] This effect is said to decrease with time since entry into the cohort. In concordance with our previous observations on workers in other Swedish plants offering unattractive work tasks,[20-22] no healthy worker selection was found among the leather tanners. We suggest that a major reason for this has been the low Swedish unemployment rates, which has not allowed the management in some industries to be very selective when employing workers.

As nasal cancer is a rare disease, large cohorts are needed to evaluate small or moderate risk excesses. In the present study two cases were observed *v* 0·5 expected, which is not conclusive, but adds some further circumstantial evidence for the hypothesis that there is an increased risk for nasal cancer in the shoe and boot industry.[3,4] On the other hand, our study did not add any evidence for an association between leather tanning and lung cancer. A higher proportion of smokers among industrial workers than in the general population,[23] is a more likely explanation for the slight increase in risk. The present data did not support associations between leather tanning and renal or bladder cancer. A numerical, but not significant, 50% increase was found for pancreatic cancer, which gives some support for the findings in a Swedish community based case-referent study.[8]

A slight and non-significant excess of prostate cancer was found among leather tanners. No specific environmental agent for prostate cancer has been identified, despite indications of an excess risk for farmers, metal workers, mechanics, repairmen, machine operators,[24] and workers manufacturing nitrate fertilisers.[25]

Chlorophenols sometimes contain high levels of polychlorinated dibenzodioxins and dibenzofurans (PCDD/Fs),[26] and consequently blood sampled from two of the tanners in plant A showed increased concentrations of these compounds.[27] Soft tissue sarcoma is the neoplasm most consistently associated with occupational exposure to PCDD/Fs although some studies do not support this hypothesis.[28] Moreover, an increased incidence of soft tissue sarcoma has recently been reported in one of the 2,3,7,8-tetrachloro-dibenzo-*p*-dioxin (TCDD) contaminated zones around Seveso.[29] Chlorophenols have also been used in the Tuscan tanning industry where an excess of soft tissue sarcoma was indicated.[14] The most plausible explanation for the increased incidence of soft tissue sarcoma in the present study is thus exposure to chlorophenols. Four of the five cases of soft tissue sarcoma had been employed during periods when chlorophenols were used in the plants.

An increased incidence of multiple myeloma in farmers has been ascribed to occupational exposure to herbicides possibly contaminated with PCDD/Fs.[30] This has gained some support from the finding of an increased incidence of myelomas among women from one of the TCDD contaminated zones around Seveso.[29] The non-significantly increased incidence of multiple myeloma in the present study may of course be a spurious finding. It is, however, noteworthy that a simultaneous excess of both soft tissue sarcoma and multiple myeloma in a cohort in which exposure to chlorophenols contaminated with PCDD/Fs has occurred. In an ongoing cohort based case-referent study, the impact of exposure to chlorophenols, benzene, halogenated organic solvents, and other carcinogens, will be analysed.

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