Cancer Incidence in Danish Phenoxy Herbicide Workers, 1947–1993

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A cohort study was undertaken of 2119 workers from Denmark who were potentially exposed to phenoxy herbicides. The workers were from two factories that produced phenoxy herbicides since 1947 and 1951, respectively. They had been employed either in the manufacture of phenoxy herbicide or in the manual service functions. The main product was 4-chloro-2-methylphenoxyacetic acid (MCPA). From 1947 to 1993 the 2119 workers had a slightly lower overall cancer incidence than the Danish population (observed = 204; expected [Exp] = 234.23; standardized incidence ratio [SIR] = 0.87; 95% confidence interval [CI] 0.8–1.0). Four soft-tissue sarcoma cases were observed (Exp = 2.47; SIR = 1.62; 95% CI = 0.4–4.1). All four cases occurred among men from Kemisk Værk Køge (Exp = 1.68; SIR = 2.38; 95% CI = 0.7–6.1). There were six cases of non-Hodgkin’s lymphomas (Exp = 5.07; SIR = 1.10; 95% CI = 0.4–2.6) and no significantly elevated risk of other cancers. Based on small numbers, the study suggests an association between the exposure to MCPA and related phenoxy herbicides and the risk of soft-tissue sarcoma. The study does not indicate a risk of non-Hodgkin’s lymphoma after exposure to these phenoxy herbicides or a risk of other cancer diseases. — Environ Health Perspect 106(Suppl 2):683–688 (1998).

Key words: cancer incidence, Denmark, non-Hodgkin’s lymphoma, phenoxy herbicide, soft-tissue sarcoma

Introduction

The dichlorophenol- and chlororesol-based phenoxy herbicides have been manufactured since the late 1940s and have been used widely for weed control in growing grains for cereals. The phenoxy herbicides based on dichlorophenols are 2,4-dichlorophenoxyacetic acid (2,4-D), 2,4-dichlorophenoxypropanoic acid (2,4-DP), and 2-(2,4-dichlorophenoxy)butyric acid (2,4-DB). Those based on chlororesol are 4-chloro-2-methylphenoxyacetic acid (MCPA), 2-(4-chloro-2-methylphenoxy)propanoic acid (MCPP), and 2-(4-chloro-2-methylphenoxy)butyric acid (MCPB). In Denmark, use of these phenoxy herbicides reached a maximum in 1983 with a total of 3000 tons. This is equivalent to approximately 0.6 kg/ inhabitants/year or to 31 kg/person working in farming.

One factory in Denmark, Kemisk Værk Køge, started to produce 2,4-D in 1947 and MCPA in 1949. MCPA soon became by far the predominant product, but a variety of other substances also was produced. Manufacture of MCPA was started in a second smaller factory in Denmark, Esbjerg Kemikaliefabrik, in 1951 (1). Cancer incidence (2,3) and mortality (4) have been studied among the 4400 workers from these two factories from 1947 to 1987. The Danish study was set up explicitly for the study of the incidence of soft-tissue sarcoma (STS) and non-Hodgkin’s lymphoma (NHL) in workers manufacturing phenoxy herbicides after the reporting of increased risks of these diseases in sprayers of phenoxy herbicides in Sweden (5,6).

The Danish cohort study of employees from the two phenoxy herbicide manufacturing plants is the only large cohort study for which cancer incidence data are available. This is particularly important for identification of STS cases. Mortality studies are less sensitive in this respect. In the International Classification of Diseases (7), visceral sarcomas are coded together with the carcinomas of the respective organs, and only the residual group of connective tissue sarcomas is coded as a separate entity. However, from the very beginning of cancer registration in Denmark in 1943, a locally adopted coding scheme has been applied where, for example, a carcinoma of the stomach is coded 151, but a sarcoma of the stomach is coded 851.

Materials and Methods

All persons ever employed in either of the two factories from the start of phenoxy herbicide manufacture until 1981 were included in the study. Data collection for the first analysis was carried out in 1981, and the cohort was not updated as Kemisk Værk Køge stopped the manufacture of phenoxy herbicides a few years later. Registration of employees was based on personnel files in the two factories, on public pension-scheme records from 1964 onwards, and on records kept by the company physician in Kemisk Værk Køge. Periodical industrial statistics data were used to control the completeness in identification of cohort members.

The total cohort included 4491 persons, of whom 4461 (99%) were successfully traced (3). They were followed through 1993 for death and emigration by linkage with the Central Population Register and for cancer incidence through the Danish Cancer Register.

Exposure measurement data were not available in the past and therefore had to be inferred from the available data on production. MCPA and, later, 2,4-DP and MCPB were the main products. At Kemisk Værk Køge, during the 1950s and 1970s, up to 50% of the MCPA was produced as spray-dried MCPA—sodium salt, a very fine powder. Small amounts of 2,4-D and negligible amounts of 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) were produced at Kemisk Værk Køge, whereas these compounds were never produced at Esbjerg Kemikaliefabrik. At various times within the phenoxy herbicide department at Kemisk Værk Køge, limited production of aniline salts, copper thalocyanin, malein hydrazide, cetyl pyridinium chloride, sodium hypochloride, and sodium acetate also took place, and purchased DDT, parathion, and dinoseb were formulated. In both factories,
other substances were produced in separate departments, including various dyes and pigments at Kemisk Værk Køge.

Workers in each plant were classified according to potential herbicide exposure based on their work area noted in the personnel files. Of the workers considered potentially to have been exposed to phenoxy herbicides in their work, 940 were employed in the phenoxy herbicide manufacturing and packaging departments and 1179 in manual service function. Thus, a total of 2119 workers potentially were exposed to phenoxy herbicides (Table 1).

Individual risk periods began with the beginning of phenoxy herbicide production—1947 at Kemisk Værk Køge and 1951 at Esbjerg Kemikaliefabrik, respectively—or on the date of first employment if this came later. The periods ended on the date of death or emigration or 31 December 1993, whichever came first. All tumors diagnosed during the individual risk periods were included in the analysis. Expected numbers of cancer cases were based on cancer incidence rates for the Danish population for sex, 5-year age, and calendar groups. As described above, both the observed (Obs) and the expected (Exp) numbers of STSs include sarcomas topographically coded to connective tissue as well as sarcomas topographically coded to organs. A standardized incidence ratio (SIR) was calculated by dividing the observed number of cases by the expected number. Confidence intervals (CI) for the SIRs were calculated under the assumption that the observed number of cases followed a Poisson distribution.

**Results**

From 1947 to 1993 the 2119 workers with potential exposure to phenoxy herbicides developed a total of four cases of STS (Exp = 2.47; SIR = 1.62; 95% CI = 0.4–4.1; 90% CI = 0.6–3.7) (Table 2). All four cases occurred among men from Kemisk Værk Køge (Exp = 1.68; SIR = 2.38; 95% CI = 0.7–6.1; 90% CI = 0.8–5.5). One patient was employed in the manufacture of phenoxy herbicides and three patients were employed in the shipping department. The employment periods varied from 3 months to 21 years. The patients were all diagnosed before 1987 and thus were included in the previous analysis of the cohort (3). One case originally diagnosed with STS in 1980 had the diagnosis changed to another disease at autopsy; this case was therefore included only in the first analysis of the data for 1947 to 1982 (2).

Two cases of STS occurred among men from Kemisk Værk Køge from departments not potentially exposed to phenoxy herbicides; one patient was employed in pigment milling and one patient in administration. The STS cases are listed in Table 3.

Persons potentially exposed to phenoxy herbicide had an incidence of NHL close to that of the Danish population (Obs = 6; Exp = 5.07; SIR = 1.10; 95% CI = 0.4–2.6) (Table 2). For completeness, it should be added that 10 NHL cases occurred among persons from Kemisk Værk Køge from departments not potentially exposed to phenoxy herbicides; this represents a clear excess risk but is not relevant for the present study.

The 2119 workers with potential exposure to phenoxy herbicides had a slightly lower overall cancer incidence than the Danish population (Obs = 204; Exp = 234.23; SIR = 0.87; 95% CI = 0.8–1.0) (Table 4).

Table 4 also lists observed and expected cancer cases by the diagnostic groups traditionally used in cancer epidemiology (8). Only cancer sites with at least two observed cases in either men or women are included in the table. The visceral sarcomas are here, according to the traditional classification, are included in the respective organ groups. No statistically significant excess risks were found. At the borderline of statistical significance were an SIR of 1.92 for cervical cancer (95% CI = 0.9–3.6) and an SIR of 1.41 for rectal cancer in men (95% CI = 0.8–2.4). An SIR of 2.24 for bladder cancer in women was found based on three cases, and an SIR of 4.55 for multiple myeloma in women based on two cases.

**Discussion**

Results of this updated analysis of the cancer incidence in the Danish cohort support the results of the previous analysis (2,3). The Danish study indicates that work in the manufacture of MCPA, MCPP, and 2,4-DP does not influence the

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**Table 1.** Number of persons employed in the phenoxy herbicide factories in Denmark, 1947–1981, by department.

| Department in factorya | Men | Women |
|------------------------|-----|-------|
| Kemisk Værk Køge      |     |       |
| Manufacture and packaging of phenoxy herbicide | 599 | 91 |
| Manual service functions | 907 | 54 |
| Manufacture of other substancesb | 1077 | 205 |
| Office | 160 | 18 |
| Unspecified | 278 | 1 |
| Total | 3021 | 369 |

| Esbjerg Kemikaliefabrik |     |       |
|------------------------|-----|-------|
| Manufacture and packaging of phenoxy herbicide | 223 | 27 |
| Manual service functions | 192 | 26 |
| Manufacture of other substancesb | 94 | 164 |
| Office | 235 | 31 |
| Unspecified | 79 | 0 |
| Total | 823 | 248 |

*These are in hierarchical order for persons who were employed in more than one department. *This is a heterogeneous group. The largest subgroup was employed in the manufacture of various organic and inorganic dyes and pigments at Kemisk Værk Køge. *One person with employment periods in both factories is included in both populations.

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**Table 2.** Observed and expected number of soft-tissue sarcoma and non-Hodgkin’s lymphoma, 1947–1993, among 2119 workers potentially exposed to phenoxy herbicide factories in two Danish factories.

|                   | Kemisk Værk Køge | Esbjerg Kemikaliefabrik | Total |
|-------------------|------------------|------------------------|-------|
|                    | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI |
| Soft-tissue sarcoma |     |     |     |       |     |     |     |       |     |     |     |       |
| Men               | 4   | 1.68| 2.38| 0.7–6.1| 0   | 0.16|     |
| Women             | 0   | 0.58| —   | —      | 0   | 0.05|     |
| Total             | 4   | 2.26| 1.77| 0.5–4.5| 0   | 0.21|     |
| Non-Hodgkin’s lymphoma |     |     |     |       |     |     |     |       |     |     |     |       |
| Men               | 5   | 3.72| 1.34| 0.4–3.1| 0   | 0.37|     |
| Women             | 1   | 0.92| 1.09| 0.03–6.1| 0   | 0.06|     |
| Total             | 6   | 4.64| 1.28| 0.5–2.8| 0   | 0.43|     |

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**Table 3.** Observed and expected number of STSs among 2119 workers potentially exposed to phenoxy herbicide factories in Denmark, 1947–1993.

|                   | Kemisk Værk Køge | Esbjerg Kemikaliefabrik | Total |
|-------------------|------------------|------------------------|-------|
|                    | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI |
| Soft-tissue sarcoma |     |     |     |       |     |     |     |       |     |     |     |       |
| Men               | 4   | 1.84| 2.18| 0.6–5.6| 0   | 0.63| —   | —      | 4   | 1.84| 2.18| 0.6–5.6 |
| Women             | 0   | 0.63| —   | —      | 0   | 0.63| —   | —      | 0   | 0.63| —   | —      |
| Total             | 4   | 2.47| 1.62| 0.4–4.1| 0   | 0.63| —   | —      | 4   | 2.47| 1.62| 0.4–4.1 |

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**Table 4.** Observed and expected number of NHLs among 2119 workers potentially exposed to phenoxy herbicide factories in Denmark, 1947–1993.

|                   | Kemisk Værk Køge | Esbjerg Kemikaliefabrik | Total |
|-------------------|------------------|------------------------|-------|
|                    | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI |
| Soft-tissue sarcoma |     |     |     |       |     |     |     |       |     |     |     |       |
| Men               | 5   | 4.09| 1.22| 0.4–2.9| 0   | 0.63| —   | —      | 5   | 4.09| 1.22| 0.4–2.9 |
| Women             | 1   | 0.98| 1.02| 0.03–5.7| 0   | 0.63| —   | —      | 1   | 0.98| 1.02| 0.03–5.7 |
| Total             | 6   | 5.07| 1.10| 0.4–2.6| 0   | 0.63| —   | —      | 6   | 5.07| 1.10| 0.4–2.6 |

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### Table 3. Soft-tissue sarcoma patients among persons employed at Kemisk Værk Kage, Denmark.

| Sex | Approximate age at diagnosis | Approximate years of diagnosis | Cancer register diagnosis | Final histology diagnosis | Cause of death (ICD-8) | Factory department | Duration of employment | Years since first employed |
|-----|-----------------------------|--------------------------------|--------------------------|--------------------------|------------------------|-------------------|---------------------|------------------------|
| Man | 50                          | 1970                           | Dermatofibrosarcoma; back | Hemangiopericytoma; back | Malignant neoplasm of unspecified origin (195.9) | Shipping           | 7 years             | 21                     |
| Man | 25                          | 1975                           | Fibrosarcoma; lower limb | Neurofibrosarcoma; lower limb | Malignant neoplasms of connective tissue in lower limb (171.3) | Shipping           | 3 months            | 5                      |
| Man | 65                          | 1975                           | Leiomyosarcoma; prostate | Leiomyosarcoma; prostate, wall of bladder or vessel | Malignant neoplasms of prostate (185.x) | Shipping           | 2.5 years           | 17                     |
| Man | 75                          | 1985                           | Angiosarcoma Kaposi; foot | Angiosarcoma Kaposi; foot | Chronic ischemic heart disease (412.9) | Manufacture of black pigments | 3 years             | 29c                    |

**Previous soft-tissue sarcoma case with potential exposure to phenoxy herbicides, included only in the analysis, 1947–1982**

| Sex | Approximate age at diagnosis | Approximate years of diagnosis | Cancer register diagnosis | Final histology diagnosis | Cause of death (ICD-8) | Factory department | Duration of employment | Years since first employed |
|-----|-----------------------------|--------------------------------|--------------------------|--------------------------|------------------------|-------------------|---------------------|------------------------|
| Man | 35                          | 1980                           | Sarcoma; retropertineum  | Alive                    | Mesenchymal tumor (cancer) | Pigment milling    | 0.5 months          | 26                     |
| Man | 55                          | 1980                           | Mesenchymal tumor, larynx | Leiomyosarcoma; larynx   | Malignant neoplasms of larynx (161.9) | Administration    | 21 years            | 37                     |
| Man | 81                          | 1980                           | Malignant histiocytoma; skin of leg | NA                      | Malignant neoplasms of ill-defined sites, other (195.9) | Administration    | 21 years            | 37                     |

NA, not applicable. *For reasons of confidentiality only approximate age and year are provided. *World Health Organization (7). *Phenoxy herbicide department from start of employment.

### Table 4. Observed and expected incident of cancer cases, 1947–1993, among 2119 workers potentially exposed to phenoxy herbicides in two Danish factories.

| ICD-7 Site | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI |
|-----------|-----|-----|-----|--------|-----|-----|-----|--------|
| 140-195   |     |     |     |        |     |     |     |        |
| 140        |     |     |     |        |     |     |     |        |
| 141        |     |     |     |        |     |     |     |        |
| 142        |     |     |     |        |     |     |     |        |
| 143        |     |     |     |        |     |     |     |        |
| 144        |     |     |     |        |     |     |     |        |
| 145        |     |     |     |        |     |     |     |        |
| 146        |     |     |     |        |     |     |     |        |
| 147        |     |     |     |        |     |     |     |        |
| 148        |     |     |     |        |     |     |     |        |
| 149        |     |     |     |        |     |     |     |        |
| 150        |     |     |     |        |     |     |     |        |
| 151        |     |     |     |        |     |     |     |        |
| 152        |     |     |     |        |     |     |     |        |
| 153        |     |     |     |        |     |     |     |        |
| 154        |     |     |     |        |     |     |     |        |
| 155        |     |     |     |        |     |     |     |        |
| 156        |     |     |     |        |     |     |     |        |
| 157        |     |     |     |        |     |     |     |        |
| 158        |     |     |     |        |     |     |     |        |
| 159        |     |     |     |        |     |     |     |        |
| 160        |     |     |     |        |     |     |     |        |
| 161        |     |     |     |        |     |     |     |        |
| 162        |     |     |     |        |     |     |     |        |

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*Not relevant. *The table includes only cancer sites with at least two observed cases in either men or women. *Includes one sarcoma case. *Includes two sarcoma cases.
Table 5. Studies on exposure to phenoxy herbicides and the risk of soft tissue sarcoma and non-Hodgkin's lymphoma. Nonmilitary work only.

| Study population | Exposure | Number of exposed cases | RR estimate | 95% CI | Number of exposed cases | RR estimate | 95% CI | Reference |
|------------------|----------|-------------------------|-------------|-------|-------------------------|-------------|-------|----------|
| Manufacture and spraying of phenoxy herbicides | | | | | | | | |
| IARC register | Potential TCDD exposure | 6 | 2.03 | (0.75–4.43) | 24 | 1.39 | (0.89–2.06) | (9) |
| IARC register | No potential TCDD exposure | 2 | 1.35 | (0.18–4.68) | 9 | 1.00 | (0.46–1.90) | (9) |
| Manufacture of phenoxy herbicides | | | | | | | | |
| BASF, Germany | TCDD exposure at accident | 0 | — | — | 0 | — | — | (20) |
| Dow Chemicals, US | 2,4-D manufacture | 2 | 3.91 | (0.44–14.11) | (21) |
| Spraying of phenoxy herbicides | | | | | | | | |
| Railway sprayers, Sweden | PH | 0 | — | — | 0 | — | — | (22) |
| Forest sprayers, Sweden | PH | 0 | — | — | 0 | — | — | (23) |
| Licenced sprayers, Sweden | PH | 7 | 0.9 | (0.4–1.9) | 21 | 1.01 | (0.63–1.54) | STS data (24) |
| Public sprayers, Finland | PH | 0 | — | — | 1 | 0.35 | (0.01–1.97) | (26) |
| Gardeners, Denmark | PH | 3 | 4.55 | (0.94–13.3) | 8 | 2.00 | (0.86–3.93) | (27) |
| Licenced sprayers, The Netherlands | PH | 0 | — | — | 0 | — | — | (28) |
| Sweden, northern | PH and/or chlorophenols | See below | 61 | 6.0 | (3.7–9.7) | (6) |
| | PH only | See below | 41 | 4.8 | (2.9–8.1) | | |
| | Chlorophenols only | See below | 25 | 8.4 | (4.2–16.9) | | |
| Sweden, middle | PH only | See below | 6 | 4.9 | (1.3–18) | (13) |
| | See below | NA | 1.3 | (0.8–2.1) | (16) | | |
| Sweden, meta-analysis | PH and/or chlorophenols | 90 | 2.8 | (2.1–4.4) | See above | (10) |
| | PH only | 59 | 2.7 | (1.9–4.7) | See above | | |
| | PH > 24 days | 40 | 3.7 | (2.4–7.8) | See above | | |
| | 2,4-D only | 46 | 3.5 | (2.3–6.7) | See above | | |
| | 2,4-D only | 5 | 1.4 | (0.4–5.1) | See above | | |
| | MCPA only | 8 | 1.6 | (0.6–5.3) | See above | | |
| | See below | NA | 1.3 | (0.8–1.9) | | |
| | PH only | NA | NA | NA | 7 | 6.0 | (1.9–19.9) | | |
| Nebraska | PH | 28 | 1.5 | (0.7–3.0) | NA | NA | NA | (29) |
| | 2,4-D only | NA | NA | NA | 13 | 1.6 | (0.7–3.6) | (75) |
| | 2,4-D only | NA | NA | NA | 13 | 1.6 | (0.7–3.6) | (75) |
| | PH ≥21 d/y | NA | NA | NA | 3 | 3.3 | (0.5–22.1) | (22) |
| Kansas | PH | 22 | 0.9 | (0.5–1.6) | 40 | 1.6 | (0.9–2.6) | (14) |
| | PH ≥21 d/y | NA | NA | NA | 7 | 6.0 | (1.9–19.9) | | |
| | See below | NA | NA | NA | 15 | 1.34 | (0.74–2.38) | (34) |
| | As above and farm was <1000 acres | PH | NA | NA | NA | 2.17 | (1.02–4.62) | (11) |
| | Italy | 2,4-D only | 4 | 2.70 | (0.6–12.4) | NA | NA | NA | (35) |
| | England and Wales farmers | PH | 9 | 1.15 | (0.83–1.59) | NA | NA | NA | (35) |
| | TCCO, chlorophenols, etc. | Seveso | TCDD in air | Zone A | 0 | — | — | 0 | — | — | (12) |
| | | Zone B | 0 | — | — | 4 | 1.7 | (0.5–4.3) | (3) |
| | | Zone R | 8 | 2.4 | (1.0–4.5) | 22 | 1.2 | (0.9–1.6) | (17) |
| | | Chlorophenols in tap water | NA | 8.9 | (1.8–44) | NA | 2.8 | (1.4–5.6) | (36) |
| | Novara and Vercelli, Italy | Men | 2,4-D and 2,4,5-TP | NA | NA | NA | 2.2 | (1.4–3.5) | (37) |
| | | Women | in water and soil | NA | NA | NA | 1.3 | NA | | |

Abbreviations: NA, not available; PH, phenoxy herbicides; RR, relative risk. *Data listed under NHL includes all malignant lymphomas. **90% confidence interval.
overall risk of cancer. This is in accordance with the result of the International Agency for Research on Cancer (IARC) multicenter study, in which the overall cancer mortality among persons exposed to phenoxy herbicides not potentially contaminated with 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) was equal to that of their national populations. The Danish cohort formed part of the IARC study.

Based on small numbers, the Danish study continues to suggest an association between exposure to MCPA, MCPP, and 2,4-DP and risk of STS. There is now quite a strong indication of an association between potential exposure to 2,4,5-T and/or TCDD and risk of STS. The evidence comes from the IARC multicenter study (9), the meta-analysis of the Swedish case-control studies (10), an Italian case-control study (11), and from the Seveso data (12) (Table 5). The overall evidence, on the other hand, is much weaker for an association between exposure to other phenoxy herbicides and risk of STS. For phenoxy herbicides not likely contaminated with TCDD, the IARC multicenter study showed an standardized mortality ratio (SMR) of 1.35 (Obs -2, where one death came from Denmark); for MCPA and 2,4-D, the Swedish meta-analysis showed relative risks of 1.6 (95% CI =0.6–5.3) and 1.4 (95% CI =0.4–5.1), respectively (Table 5).

It is clear that the suggested excess risk of STS in the Danish cohort study was detected only because the national cancer incidence data from the very beginning of registration in 1943 included separate codes for visceral sarcomas. Only one of the four visceral sarcoma patients had a sarcoma topographically coded to the connective tissue. The sensitivity of epidemiologic studies on STS thus depends highly on the data source, and the Danish coding scheme ensures that all STSs are identified. The study does not support an association between phenoxy herbicide exposure and subsequent risk of NHL. At present, the findings from various studies on the risk of NHL following exposure to phenoxy herbicides are equivocal. Excess risks were indicated in some Swedish (6,13) and American (14,15) case-control studies but not in all (16,17). In the IARC multicenter study (19) and in the Seveso data (12) the risks are slightly but statistically nonsignificantly elevated among persons with potential exposure to TCDD, whereas the risk was not elevated in the IARC study population without potential exposure to TCDD.

The borderline excess risk of cervical cancer in the present study is unexplained. Women with potential exposure to phenoxy herbicides worked mainly in the packaging and cleaning areas. Packaging was seasonal work and the workers came mainly from surrounding rural areas. Women who farm in Denmark, however, have a deficit risk of cervical cancer (18). Two cases of multiple myeloma occurred among women in the study. Although there are some indications in the literature for a possible association between exposure to phenoxy herbicides and multiple myeloma (19), the literature is not consistent. It therefore seems prudent not to overinterpret the finding of an excess risk in the Danish study based on only two cases.

When data were collected for the present study, considerable efforts were made to ensure a complete ascertainment of the cohort members, using both personnel files and files kept by the company doctors, public pension scheme data, and data from the periodical industrial statistics (1). No healthy worker effect was apparent in the cohort, in which the overall mortality during the first 35 years of follow-up was close to that of the Danish population (4). Cohort members from the phenoxy herbicide departments were exposed predominantly but not exclusively to phenoxy herbicides, but none of the other exposures that occurred in the phenoxy herbicide departments are known to be clearly related to a risk of STS.

Based on the foregoing data, it may be concluded that this Danish study indicates that work in the manufacture of MCPA, MCPP, and 2,4-DP does not increase the overall risk of cancer. Based on small numbers, this very sensitive Danish study continues to suggest an association between exposure to these phenoxy herbicides and risk of STS. The study does not support an association between phenoxy herbicide exposure and risk of NHL.

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