

## DANISH OCCUPATIONAL GROUPS AT HIGH RISK OF CANCER OF SPECIFIC SITES

The detailed occupational classification was used in the analysis in the following three different ways: (i) to assess the validity of the linked register, (ii) to use the linked register as a library for the documentation of associations reported in the literature, and (iii) to search for new associations.

### Assessment of validity

The validity of the linked register was assessed from a tabulation of combinations of detailed occupational groups and cancer sites, which were assumed to reflect classic associations between occupational exposures and cancer risks. The classic associations, which were used for illustration in this report, have all been covered by in-depth epidemiologic studies in the Nordic countries.

A relative risk of about three was found for cancer of the lip in relation to outdoor work in a Finnish case-referent study (93). Table 16 shows that an excess risk for cancer of the lip was found in the Danish linked register for both self-employed men and for unskilled workers employed in agriculture and fishing, both being industries with outdoor work. The relative risk was about two for the two groups of men in agriculture (RR 1.85, 95 % CI 1.6—2.1) and somewhat higher for the two groups of men in fishing (RR 3.64, 95 % CI 2.3—5.5).

Owners of restaurants, waiters, and brewery workers are all occupational groups with easy access to alcohol at the workplace. A relative risk of 1.5 was found for cancer of the liver among male brewery workers in a cohort study in Denmark (94). In the linked register an excess risk of liver cancer was found for all the three occupational groups, as shown in

table 16. The overall relative risk was 4.12 (95 % CI 2.6—6.2).

A Danish cohort study of workers from an asbestocement factory showed a relative risk of 5.6 for pleural mesothelioma (95). Data were retrieved from the linked register for occupational groups with potential exposure to asbestos. An excess risk was observed both among the skilled blacksmiths and among the skilled machinists working in shipyards (RR 11.24, 95 % CI 5.4—20.7), but no case was observed among the unskilled workers in shipyards, despite an expected number of 0.67. One case was observed in the small group of unskilled insulation workers. Excess risks were observed for both self-employed and skilled plumbers, for whom the total relative risk was 7.06 (95 % CI 2.6—15.4).

A Danish case-referent study showed a relative risk of 30.4 for adenocarcinoma of the nasal cavity in relation to wood dust exposure (96). The data in the linked register did not allow a distinction to be made between different histological types of nasal cancer. But the register showed an excess risk of cancer of the nasal cavities and sinuses for both self-employed and skilled furniture workers, who are potentially exposed to hard wood dust (RR 12.86, 95 % CI 5.9—24.4), but no case was observed among unskilled workers in furniture manufacturing, for which 0.44 cases were expected.

The fact that some of the classic associations were found for self-employed and skilled workers, but not for unskilled workers in the same industry is in accordance with the late transition in Denmark from an agricultural to an industrial society. At least one-quarter of the unskilled workers in industry at the time of the 1970 census had a background in agriculture,

**Table 16.** Cancer incidence for selected sites and selected occupations among the men in 1970–1980. (O = observed number of cases, E = expected number of cases, RR = relative risk, 95 % CI = 95 % confidence interval)

| Cancer site <sup>a</sup>                | Number of persons | O   | E      | RR    | 95 % CI    |
|-----------------------------------------|-------------------|-----|--------|-------|------------|
| <b>Lip (140)</b>                        |                   |     |        |       |            |
| Self-employed, farmers                  | 100 122           | 182 | 101.37 | 1.80  | 1.55–2.08  |
| Unskilled workers, agriculture          | 33 532            | 43  | 20.58  | 2.09  | 1.55–2.82  |
| Self-employed, fishing                  | 5 772             | 15  | 4.56   | 3.29  | 1.84–5.42  |
| Unskilled workers, fishing              | 4 452             | 7   | 1.49   | 4.70  | 1.89–9.68  |
| <b>Liver (155.0)</b>                    |                   |     |        |       |            |
| Self-employed, hotels, restaurants      | 4 084             | 8   | 2.14   | 3.74  | 1.61–7.36  |
| Skilled workers, waiters                | 4 405             | 7   | 1.41   | 4.96  | 1.99–10.23 |
| Unskilled workers, breweries            | 4 483             | 8   | 2.03   | 3.94  | 1.70–7.76  |
| <b>Pleura, mesothelioma (462.2)</b>     |                   |     |        |       |            |
| Skilled blacksmiths, shipyards          | 5 604             | 6   | 0.63   | 9.57  | 3.49–20.73 |
| Skilled machinists, shipyards           | 2 346             | 4   | 0.26   | 15.19 | 4.19–39.38 |
| Unskilled workers, shipyards            | 3 759             | —   | 0.67   | —     | —          |
| Unskilled workers, insulation           | 842               | 1   | 0.09   | 10.59 | 0.28–61.89 |
| Self-employed, plumbers                 | 2 943             | 4   | 0.45   | 8.86  | 2.42–22.76 |
| Skilled workers, plumbers               | 6 414             | 2   | 0.40   | 4.99  | 0.61–18.05 |
| <b>Nasal cavities and sinuses (160)</b> |                   |     |        |       |            |
| Self-employed, furniture makers         | 1 421             | 3   | 0.21   | 14.29 | 2.95–41.76 |
| Skilled workers, furniture makers       | 4 697             | 6   | 0.49   | 12.25 | 4.49–26.65 |
| Unskilled workers, furniture factories  | 3 572             | —   | 0.44   | —     | —          |

<sup>a</sup> Codes of the International Classification of Diseases, seventh revision, in parentheses, from reference 83.

**Table 17.** Cancer incidence for lung cancer among male butchers and farmers in 1970–1980. (O = observed number of cases, E = expected number of cases, RR = relative risk, 95 % CI = 95 % confidence interval)

| Occupation                           | Number of persons | O   | E      | RR   | 95 % CI   |
|--------------------------------------|-------------------|-----|--------|------|-----------|
| <b>Butcher's shop</b>                |                   |     |        |      |           |
| Self-employed                        | 3088              | 55  | 32.89  | 1.67 | 1.28–2.18 |
| Skilled butcher                      | 2785              | 20  | 11.19  | 1.79 | 1.09–2.76 |
| <b>Slaughterhouse</b>                |                   |     |        |      |           |
| Skilled butcher                      | 4828              | 44  | 26.73  | 1.65 | 1.23–2.22 |
| Unskilled worker                     | 8021              | 60  | 60.59  | 0.99 | 0.77–1.28 |
| <b>Unskilled worker, agriculture</b> |                   |     |        |      |           |
|                                      | 33564             | 191 | 265.67 | 0.72 | 0.62–0.83 |
| Farmer II                            | 30892             | 206 | 506.08 | 0.41 | 0.36–0.47 |
| Farmer I                             | 69369             | 353 | 887.94 | 0.40 | 0.36–0.44 |

whereas the self-employed and skilled workers had served an apprenticeship in their trade at an early age.

The labor market structure is thus an important factor to take into consideration in the interpretation of results from a linked register. This point is further illustrated by the example of lung cancer among butchers.

The excess risk of lung cancer among butchers was observed in Denmark among self-employed and skilled butchers in butcher's shops, and among skilled butchers in slaughterhouses, but not among the unskilled workers (56). Skilled butchers and unskilled workers in Danish slaughterhouses normally have the same jobs, namely, meat cutting and sausage making. A survey in 1983 also showed the two groups to have almost similar smoking habits. However, only 1.5 % of the

skilled butchers had worked in agriculture for more than five years, in contrast to 40 % of the unskilled workers. The lung cancer risk measured for unskilled workers in slaughterhouses in the linked study was equivalent to the average for all economically active men (RR 0.99). It thus fell between the excess risk found for the skilled butchers (RR 1.65–1.79) and the deficit risk found in agriculture (RR 0.40–0.72). (See table 17.)

### Library for documentation

Associations that show up in case reports, in epidemiologic studies, or in other surveillance systems can be further elucidated by retrieval of the relevant data from the linked register. Given the sparseness of information available on the individual person in the linked register, it is, however, important not to consider this use of the register as being equivalent to a test of a hypothesis. It is particularly important not to use the registers to dismiss previous observations. The turnover on the labor market and the occupational titles, which are relatively nonspecific when it comes to exposures, tend to introduce a negative bias in the observations from a register. Four examples of the use of the linked register as a library for the documentation of observations reported in the literature are given in the following discussion.

An excess risk of bladder cancer but not of lung cancer was reported for men in a cohort of hairdressers from Geneva (97). The linked register showed a relative risk of bladder cancer of about two for both male (RR 2.05, 95 % CI 1.5–2.8) and female (RR

1.76, 95 % CI 0.7—3.6) hairdressers in Denmark. The risk of lung cancer was close to that of all economically active people (RR 1.11, 95 % CI 0.9—1.4). (See table 18.)

A literature review provided support for the hypothesis of a risk for malignant melanomas in the printing industry, especially among lithographers (98). This observation was, however, not supported by the data in the linked register. The incidence of malignant melanoma for persons working in the printing industry was close to the average for the economically active population (RR 0.95, 95 % CI 0.5—1.6), and no case was observed among the lithographers, whereas 1.67 cases were expected. Printing work might vary, however, and a survey in Danish printing workshops showed a total of 2000 products to be in use (99).

The third example concerns leukemia in farmers, for whom a literature review showed relative risks greater than one in more than 50 % of the reviewed studies (100). The linked register showed no excess risk of leukemia among people on the majority of farms in Denmark, where the farmer is a man and where the wife is actively working on the farm in about 40 % of the cases. The relative risk of leukemia in this large population was 0.92 for the men and 0.89 for the women. There was, however, a hint of an excess risk of leukemia among persons on the minority of farms where the farmer was a woman. In this small population one leukemia case was observed among the men and eight cases among the women for a total relative risk of 2.37 (95 % CI 1.1—4.5). In order to pursue this hypothesis further in Denmark, one should therefore concentrate on the work processes on this minority of farms.

The last example concerns brain tumors among dentists and dental nurses, for whom the Swedish cancer environment register showed an excess risk (RR 1.8), especially for glioblastoma (RR 2.1) (101). This observation could not be confirmed in the Danish linked register, where a total of nine brain tumors was observed for the dentists and dental nurses (RR 1.26, 95 % CI 0.6—2.4). Only one of the Danish cases was a glioblastoma.

## Search for new associations

The search for previously unknown associations between specific occupations and cancers is one of the main potentials of a linked register. In this study the cancer incidence was tabulated for 42 cancer sites among the men in 492 detailed occupational groups and for 44 cancer sites among the women in 447 detailed occupational groups. The cells that indicated an excess risk were of particular interest.

The total data set for economically active persons aged 20—64 years on the date of the census included, however, only 2 million persons and 77 000 incident cancer cases. For most cancer sites both the observed

**Table 18.** Cancer incidence for selected sites and selected occupations among the men and women in 1970—1980. (O = observed number of cases, E = expected number of cases, RR = relative risk, 95 % CI = confidence interval)

| Cancer site <sup>a</sup>                        | Number of persons | O   | E      | RR    | 95 % CI    |
|-------------------------------------------------|-------------------|-----|--------|-------|------------|
| Bladder including papilloma (181)               |                   |     |        |       |            |
| Self-employed and skilled workers, hairdressers |                   |     |        |       |            |
| Men                                             | 4874              | 41  | 19.97  | 2.05  | 1.51—2.78  |
| Women                                           | 9497              | 7   | 3.97   | 1.76  | 0.71—3.63  |
| Melanoma (190)                                  |                   |     |        |       |            |
| Typographers                                    |                   |     |        |       |            |
| Men                                             | 11878             | 7   | 9.01   | 0.78  | 0.31—1.60  |
| Women                                           | 546               | 1   | 0.57   | 1.75  | 0.04—9.77  |
| Lithographers                                   |                   |     |        |       |            |
| Men                                             | 2265              | 0   | 1.46   | —     | —          |
| Women                                           | 257               | 0   | 0.21   | —     | —          |
| Photoengravers                                  |                   |     |        |       |            |
| Men                                             | 1187              | 0   | 0.82   | —     | —          |
| Women                                           | 123               | 1   | 0.06   | 16.67 | 0.42—92.83 |
| Bookbinders                                     |                   |     |        |       |            |
| Men                                             | 1518              | 2   | 1.15   | 1.74  | 0.21—6.29  |
| Women                                           | 2386              | 4   | 2.56   | 1.56  | 0.43—43.06 |
| Leukemia (204)                                  |                   |     |        |       |            |
| Farmers, head of farm a man                     |                   |     |        |       |            |
| Men                                             | 100273            | 145 | 157.57 | 0.92  | 0.78—1.08  |
| Women                                           | 40673             | 27  | 30.48  | 0.89  | 0.58—1.29  |
| Farmers, head of farm a woman                   |                   |     |        |       |            |
| Men                                             | 124               | 1   | 0.19   | 5.26  | 0.13—29.32 |
| Women                                           | 2775              | 8   | 3.60   | 2.22  | 0.96—4.38  |
| Brain (193)                                     |                   |     |        |       |            |
| Dentists and dental nurses                      |                   |     |        |       |            |
| Men                                             | 1970              | 2   | 2.44   | 0.82  | 0.10—2.96  |
| Women                                           | 5186              | 7   | 4.68   | 1.50  | 0.60—3.08  |

<sup>a</sup> Code of the International Classification of Diseases, seventh revision, in parentheses, from reference 83.

and the expected numbers of cancer cases were therefore relatively small for each of the detailed occupational groups. An example is cancer of the lip among the women, for whom the observed number was zero and the expected number was close to zero in 409 of the 447 detailed occupational groups. (Data for all the occupational groups can be obtained from the Danish Cancer Registry upon request.) We have selected therefore only those cells for which “observed > (expected + expected<sup>1/2</sup>),” as illustrated for numbers up to 20 in table 19. (Data for the selected occupational groups can be obtained from the Danish Cancer Registry upon request.)

A detailed occupational classification often includes more than one group from a particular trade (eg, bricklayer as a skilled worker and bricklayer as a self-employed person). It is therefore possible to group the high-risk occupations for a certain cancer site according to related work tasks. Such clusters of high-risk occupations may give rise to speculations about possible etiologic factors. Examples of clusters observed in the linked register follow.

**Table 19.** Limits used for the tabulation of the high-risk occupational groups.

| Expected number<br>of cancer cases <sup>a</sup> | Observed number of cancer cases |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
|-------------------------------------------------|---------------------------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|
|                                                 | 0                               | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 0—1                                             |                                 |   | x | x | x | x | x | x | x | x | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  |
| 1—2                                             |                                 |   |   | x | x | x | x | x | x | x | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  |
| 2—3                                             |                                 |   |   |   | x | x | x | x | x | x | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  |
| 3—4                                             |                                 |   |   |   |   | x | x | x | x | x | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  |
| 4—5                                             |                                 |   |   |   |   |   | x | x | x | x | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  |
| 5—6                                             |                                 |   |   |   |   |   |   | x | x | x | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  |
| 6—7                                             |                                 |   |   |   |   |   |   |   | x | x | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  |
| 7—8                                             |                                 |   |   |   |   |   |   |   |   | x | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  |
| 8—9                                             |                                 |   |   |   |   |   |   |   |   |   | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  |
| 9—10                                            |                                 |   |   |   |   |   |   |   |   |   |    | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  |
| 10—11                                           |                                 |   |   |   |   |   |   |   |   |   |    |    | x  | x  | x  | x  | x  | x  | x  | x  | x  |
| 11—12                                           |                                 |   |   |   |   |   |   |   |   |   |    |    |    | x  | x  | x  | x  | x  | x  | x  | x  |
| 12—13                                           |                                 |   |   |   |   |   |   |   |   |   |    |    |    |    | x  | x  | x  | x  | x  | x  | x  |
| 13—14                                           |                                 |   |   |   |   |   |   |   |   |   |    |    |    |    |    | x  | x  | x  | x  | x  | x  |
| 14—15                                           |                                 |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    | x  | x  | x  | x  | x  |
| 15—16                                           |                                 |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    | x  | x  | x  |

<sup>a</sup> Includes 0.00—0.99, etc.

### Examples of high-risk occupations among the men

Table 20 shows the high-risk occupations for cancer of the larynx in men. For some of the 58 high-risk groups, the occupational titles indicate exposure to known risk factors for laryngeal cancer. Workers in “restaurants and breweries” were thus expected to have an excess alcohol consumption (102). Workers in shipyards and construction may have been exposed to asbestos (103). Not all of the excess risks seemed, however, to be associated with known risk factors. Examples are the excess risk of laryngeal cancer among butchers, bakers, and drivers and among metal workers in engineering works, including both the smiths, mechanics, foremen, and shop owners. Engineering work covers the manufacturing, fitting, and repair of a broad variety of machines and will thus imply various workplace exposures, including welding. Welding as a risk factor for laryngeal cancer has been studied previously in a case-referent study in Denmark. The study showed a moderately increased risk (RR 1.3, 95 % CI 0.9—2.0) when alcohol and tobacco were controlled for (104).

Examples of clusters of high-risk occupations pointing to possible new associations are shown for other cancer sites in table 21. An excess risk of leukemia was found among the men employed in banking and finance. When combined, senior and other banking staff and cashiers, all directly engaged with money handling, have a doubled risk of leukemia (RR 2.07, 95 % CI 1.3—3.2). Women with the equivalent occupations have a moderately increased risk of leukemia (RR 1.31, 95 % CI 0.5—2.9). When this observation is regarded as hypothesis-generating, it is, however, important to remember that the average seniority on the labor market is shorter for women in these generations than for men.

The linked register also showed an excess risk of leukemia in some occupational groups engaged in

animal handling. These groups were veterinarians, owners of special farms (mink, chicken, horse, dog, bee, and pig breeding) and tractor drivers from experimental farms.

Leukemia among agricultural workers in Denmark thus shows a pattern of no excess risk among the majority of farmers but an indication of an excess risk for a minority of farms on which the farmer is a woman, and some special occupational groups engaged with animal handling show up as high-risk groups for leukemia. These observations are compatible with observations from, for example, Sweden, where there was no excess risk of leukemia among farmers (105), and from New Zealand, where the odds ratio for leukemia on “general and unspecified farms” was 1.24 (95 % CI 0.9—1.7) but 3.00 (95 % CI 1.2—7.3) for “live-stock farms” (32).

There was a cluster of occupational groups at high risk for primary liver cancer in the printing industry. These groups were lithographers, bookbinders, and typographers from newspapers. There was no excess risk of primary liver cancer among typographers from bookprinting, and there was no excess risk among the relatively large group of women working with bookbinding. The printing industry has, however, been characterized by the use of a broad variety of chemical products.

Work in the printing industry did not appear as a high-risk occupation in any of three case-referent studies on primary liver cancer in the United States (106—108). High-grade exposure to solvents was related to an excess risk of primary liver cancer in Sweden (RR 1.8, 95 % CI 1.0—3.4) (109), and exposure to solvents was associated with an excess risk of primary liver cancer among women (RR 3.4, 90 % CI 1.3—8.6) but not among men (RR 0.6, 90 % CI 0.3—1.3) in Finland (110, 111).

The cluster of excess risks of primary liver cancer found for artists and ceramists is of interest. These oc-

cupational groups were relatively small, but one additional case of primary liver cancer occurred among the female artists. The group of artists included art painters, sculptors, and some musicians. The male and female glass makers, ceramists, and artists together had a sevenfold risk of primary liver cancer (RR 6.86, 95 % CI 2.8–14.1). This excess risk was contrasted by no deaths from primary liver cancer among male art painters identified from artists' obituaries in the United States (112).

There was a cluster of health care personnel with an excess risk of cancer of the kidney among the men. Occupational exposure to and/or intake of certain drugs is a possible etiologic factor to be considered. Among one-fourth of the kidney cancer cases among the men were cancers of the renal pelvis, which are known to be associated with intake of analgesic mixtures containing phenacetin (113). The remaining three-fourths of the cases were renal cell cancers for which an association with phenacetin-containing analgesics has also been observed in some studies (114). There was, however, in general no excess risk of cancer of the kidney among the women in the health care sector in the linked register, not even among the nurses, who normally have a long seniority, and the possible explanations for the excess risk observed among the men needs to be scrutinized further.

Owners of filling stations also had an excess risk of kidney cancer. This was a relatively small group, however, and no case was found of kidney cancer among the wives actively working in the filling stations. A case-referent study in Montreal showed an excess risk of kidney cancer related to exposure to aviation gasoline and jet fuel, but not to automotive gasoline (115).

### Examples of high-risk occupations among the women

Examples of clusters of high-risk occupational groups among the women are shown in table 22. Two occupational groups from textile manufacturing and sales showed up as high-risk groups for cancer of the tongue. When the data were aggregated over the four groups of seamstresses in the detailed occupational classification, a total of five cases of cancer of the tongue were observed for a fivefold excess risk (RR 5.38, 95 % CI 1.7–12.5). The seamstresses had, however, only a moderately elevated risk of cancer of the mouth (RR 1.61, 95 % CI 0.4–4.1), and no excess risk of cancer of the pharynx (RR 0.83, 95 % CI 0.1–3.0).

Three case-referent studies from the United States have shown conflicting results for cancer of the buccal cavity and pharynx among female textile workers. A relative risk of 1.56 was found for textile workers in Atlanta, Georgia, in 1956–1957 (116) (included also cancer of the larynx), a relative risk of 5.71 was found for operatives in apparel in New York in 1956–1965 (33), and a relative risk of 1.4 was found in North

**Table 20.** Cancer incidence for cancer of the larynx<sup>a</sup> in high-risk occupational groups in 1970–1980. (O = observed number of cases, E = expected number of cases, RR = relative risk)

| Occupation                                   | Number of persons | O  | E     | RR   |
|----------------------------------------------|-------------------|----|-------|------|
| <b>Restaurants and breweries</b>             |                   |    |       |      |
| Waiter                                       | 4403              | 19 | 2.99  | 6.36 |
| Matron, catering officer                     | 768               | 3  | 0.49  | 6.15 |
| Self-employed/hotel-restaurant               | 4082              | 10 | 4.50  | 2.22 |
| Factory hand/brewery                         | 4483              | 13 | 4.29  | 3.03 |
| <b>Butchers and bakers</b>                   |                   |    |       |      |
| Butcher/butcher's shop                       | 2785              | 3  | 1.14  | 2.63 |
| Butcher/slaughterhouse                       | 4828              | 5  | 2.64  | 1.89 |
| Factory hand/slaughterhouse                  | 8022              | 14 | 6.10  | 2.29 |
| Baker                                        | 5080              | 5  | 3.46  | 1.45 |
| Self-employed/baker's shop                   | 3456              | 6  | 3.73  | 1.61 |
| <b>Drivers</b>                               |                   |    |       |      |
| Bus driver in public service                 | 2006              | 4  | 2.19  | 1.82 |
| Driver/tramway-omnibus                       | 2359              | 5  | 2.09  | 2.39 |
| Driver/other trade                           | 11460             | 11 | 7.44  | 1.48 |
| Self-employed/taxi                           | 4438              | 8  | 4.51  | 1.77 |
| Self-employed/haulage contractor             | 3476              | 5  | 2.96  | 1.69 |
| Self-employed/other transport                | 1397              | 3  | 1.47  | 2.04 |
| Driver/food industry                         | 4673              | 7  | 3.45  | 2.03 |
| Driver/all other                             | 4060              | 5  | 3.41  | 1.47 |
| Crane driver/building                        | 6389              | 5  | 2.78  | 1.80 |
| Driver/soldier, industry NOS                 | 4419              | 4  | 2.25  | 1.78 |
| <b>Seamen and pilots</b>                     |                   |    |       |      |
| Self-employed/fishing                        | 5789              | 11 | 5.56  | 1.98 |
| Stoker/all other                             | 2221              | 6  | 3.15  | 1.91 |
| Sea captain, pilot                           | 3905              | 5  | 2.66  | 1.88 |
| <b>Chemical industry</b>                     |                   |    |       |      |
| Factory hand/chemical industry               | 6169              | 13 | 6.37  | 2.04 |
| Factory hand/rubber factory                  | 1729              | 3  | 1.40  | 2.14 |
| Factory hand/stone, clay, glass industry     | 6890              | 10 | 7.09  | 1.41 |
| <b>Building</b>                              |                   |    |       |      |
| Plumber                                      | 6414              | 4  | 2.38  | 1.68 |
| Smith/plumber                                | 2674              | 3  | 1.01  | 2.97 |
| Bricklayer                                   | 15247             | 19 | 8.85  | 2.15 |
| Carpenter/carpenter                          | 13184             | 10 | 5.50  | 1.82 |
| Self-employed/other civil engineering        | 2992              | 7  | 2.75  | 2.54 |
| <b>Shipyard</b>                              |                   |    |       |      |
| Smith/shipyard                               | 5603              | 6  | 3.78  | 1.59 |
| Mechanic, toolmaker/shipyard                 | 2346              | 5  | 1.56  | 3.21 |
| Factory hand/shipyard                        | 3758              | 8  | 3.94  | 2.03 |
| Boatbuilder                                  | 1279              | 4  | 0.86  | 4.63 |
| <b>Metal industry</b>                        |                   |    |       |      |
| Self-employed/engineering workshop           | 3680              | 6  | 4.01  | 1.50 |
| Smith/engineering workshop                   | 6093              | 4  | 2.16  | 1.85 |
| Smith/engineering work                       | 5744              | 5  | 2.65  | 1.89 |
| Mechanic, toolmaker/engineering work         | 13287             | 10 | 6.86  | 1.46 |
| Foreman/engineering works                    | 4215              | 6  | 3.30  | 1.82 |
| Smith/metal industry                         | 5406              | 6  | 2.45  | 2.45 |
| Fitter/metal industry                        | 4701              | 6  | 2.33  | 2.57 |
| Factory hand/iron-steel industry             | 4079              | 6  | 4.00  | 1.50 |
| Self-employed/car-motorcycle repair workshop | 4654              | 7  | 3.50  | 2.00 |
| <b>Shop assistants</b>                       |                   |    |       |      |
| Superior shop staff/wholesale trade          | 6674              | 8  | 5.33  | 1.50 |
| Superior shop staff/all other                | 7688              | 10 | 6.89  | 1.45 |
| Shop assistant/department store              | 794               | 3  | 0.55  | 5.48 |
| <b>Mixed</b>                                 |                   |    |       |      |
| Self-employed/household utensil              | 6981              | 12 | 7.36  | 1.63 |
| Self-employed/cleaning                       | 2051              | 4  | 2.37  | 1.69 |
| Fireman                                      | 874               | 4  | 0.73  | 5.45 |
| Actor                                        | 766               | 2  | 0.45  | 4.49 |
| Foreman/radio-television production          | 2068              | 5  | 1.68  | 2.97 |
| Hospital orderly                             | 3192              | 4  | 2.25  | 1.78 |
| Typographer/newspaper                        | 3137              | 4  | 2.09  | 1.91 |
| Draftsman                                    | 4546              | 4  | 1.76  | 2.27 |
| <b>Noninformative occupations</b>            |                   |    |       |      |
| Porter/real estate administration            | 3285              | 8  | 4.10  | 1.95 |
| Porter/all other                             | 2996              | 8  | 3.57  | 2.24 |
| Factory hand/manufacture NOS                 | 16166             | 20 | 11.70 | 1.71 |
| Occupation NOS/industry NOS                  | 14824             | 13 | 7.89  | 1.65 |

<sup>a</sup> Code 161 of the seventh revision of the International Classification of Diseases, from reference 83.

**Table 21.** Cancer incidence for leukemia and cancer of the liver and kidney in selected high-risk occupational groups of men in 1970–1980. (O = observed number of cases, E = expected number of cases, RR = relative risk)

| Occupation                                 | Number of persons | O  | E    | RR    |
|--------------------------------------------|-------------------|----|------|-------|
| <i>Leukemia (204)<sup>a</sup></i>          |                   |    |      |       |
| <i>Finance</i>                             |                   |    |      |       |
| Self-employed/financial institution        | 1465              | 4  | 2.21 | 1.81  |
| Other banking staff                        | 5393              | 4  | 1.68 | 2.38  |
| Senior banking staff                       | 6231              | 11 | 6.58 | 1.67  |
| Cashier                                    | 863               | 5  | 1.38 | 3.63  |
| Self-employed/accounting                   | 1930              | 8  | 2.51 | 3.18  |
| <i>Animal handling</i>                     |                   |    |      |       |
| Self-employed/veterinary practice          | 735               | 3  | 0.92 | 3.26  |
| Self-employed/special farm                 | 1952              | 5  | 2.75 | 1.82  |
| Tractor driver/agricultural services       | 1249              | 3  | 0.64 | 4.68  |
| <i>Liver (155.0)<sup>a</sup></i>           |                   |    |      |       |
| <i>Printing</i>                            |                   |    |      |       |
| Lithographer                               | 1618              | 4  | 0.29 | 13.71 |
| Bookbinder                                 | 1146              | 2  | 0.32 | 6.34  |
| Typographer/newspaper                      | 3140              | 4  | 0.98 | 4.10  |
| <i>Artists and ceramists</i>               |                   |    |      |       |
| Self-employed/artist                       | 1398              | 3  | 0.68 | 4.41  |
| Ceramist                                   | 388               | 2  | 0.14 | 13.93 |
| <i>Kidney (180)<sup>a</sup></i>            |                   |    |      |       |
| <i>Health care</i>                         |                   |    |      |       |
| Pharmacist                                 | 625               | 3  | 0.72 | 4.17  |
| Self-employed/pharmacy                     | 264               | 4  | 0.81 | 4.97  |
| Self-employed/medical practice             | 1967              | 6  | 4.29 | 1.40  |
| Assistant nurse/all other                  | 546               | 2  | 0.40 | 5.06  |
| Veterinary surgeon (not with own practice) | 636               | 4  | 1.15 | 3.48  |
| <i>Gasoline</i>                            |                   |    |      |       |
| Self-employed/filling stations             | 1988              | 4  | 2.22 | 1.80  |

<sup>a</sup> Code of the International Classification of Diseases, seventh revision, in parentheses, from reference 83.

Carolina in 1975–1978 for women with 10 or more years in apparel (117). A case-referent study from England & Wales from the late 1970s showed a relative risk of 4.47 for women working in an area where the textile work was predominantly with cotton, whereas the risk was not increased for men in the same area, and neither for women and men in an area where the textile work was predominantly with wool (38). These observations leave open the possibility of an association between certain types of textile work (eg, seamstress/operative in apparel) and oral cancer, maybe only cancer of the tongue.

There was a cluster of women in leading administrative positions with an excess risk of stomach cancer. This occurrence reflects the social gradient related with stomach cancer. Female academics thus had a slightly increased risk of stomach cancer (RR 1.48), whereas male academics had a decreased risk of stomach cancer (RR 0.61). Suicides showed a social pattern similar to that of stomach cancer. Female academics had an increased risk for suicide (RR 2.10) but male academics did not (RR 0.93) (15).

There also seemed to be an excess risk of stomach cancer among female gardeners. A similar increase was not seen for the male gardeners. The two groups did, however, not necessarily have the same work tasks. A survey of gardeners in Denmark in 1982 showed 36 %

**Table 22.** Cancer incidence for the tongue, stomach, brain, and thyroid in selected high-risk occupational groups of women in 1970–1980. (O = observed number of cases, E = expected number of cases, RR = relative risk)

| Occupation                            | Number of persons | O | E    | RR    |
|---------------------------------------|-------------------|---|------|-------|
| <i>Tongue (141)<sup>a</sup></i>       |                   |   |      |       |
| <i>Textile</i>                        |                   |   |      |       |
| Seamstress/all other                  | 4704              | 2 | 0.20 | 9.84  |
| Self-employed/textile                 | 2311              | 2 | 0.17 | 11.92 |
| <i>Stomach (151)<sup>a</sup></i>      |                   |   |      |       |
| <i>Head of administration</i>         |                   |   |      |       |
| Senior staff in public administration | 712               | 3 | 0.75 | 4.03  |
| Senior banking staff                  | 963               | 3 | 0.70 | 4.29  |
| Head of social institution            | 2827              | 5 | 2.98 | 1.68  |
| <i>Gardening</i>                      |                   |   |      |       |
| Gardener's laborer                    | 2111              | 4 | 1.97 | 2.03  |
| Family worker/gardening               | 2534              | 6 | 2.63 | 2.28  |
| <i>Brain (193)<sup>a</sup></i>        |                   |   |      |       |
| <i>Health care</i>                    |                   |   |      |       |
| Physiotherapist                       | 2965              | 5 | 3.20 | 1.56  |
| Self-employed/nursing agency          | 1045              | 4 | 1.65 | 2.43  |
| Physicians (not with own practice)    | 975               | 4 | 1.07 | 3.75  |
| Dental assistant                      | 3745              | 5 | 2.96 | 1.69  |
| <i>Thyroid (194)<sup>a</sup></i>      |                   |   |      |       |
| <i>Stewardess and matron</i>          |                   |   |      |       |
| Stewardess                            | 420               | 2 | 0.08 | 25.22 |
| Matron, catering officer              | 4915              | 3 | 1.07 | 2.81  |
| <i>Librarian</i>                      |                   |   |      |       |
| Librarian                             | 1791              | 2 | 0.32 | 6.20  |

<sup>a</sup> Code of the International Classification of Diseases, seventh revision, in parentheses, from reference 83.

to have worked with pesticides during the last year, most often used for potted plants. Four percent had experienced symptoms of nausea, vomiting, and diarrhea in relation to the use of pesticides (118).

There was a cluster of high-risk occupations for brain tumors among the women from the health care sector. Physiotherapists and self-employed persons with nursing agencies, of whom the majority were physiotherapists, together had a relative risk of 1.86 (95 % CI 0.8–3.5). There were few male physiotherapists in Denmark in 1970. The female physicians without their own practice and the small group of female physicians with their own practice together had a relative risk of 3.27 (95 % CI 1.1–7.6). A relative risk of 1.96 (95 % CI 1.1–3.2) was found for male physicians. There was no excess risk of brain tumors among the large group of nurses. Dental nurses, however, were a high-risk group, but the linked register did not show a generally increased risk of brain tumors among dentists and dental nurses, as has already been mentioned.

An excess risk of brain tumors among “health diagnosing professionals” but not in “health treating occupations” have also been found for various areas of the United States (119), and pathologists, anatomists, and embalmers have been found to be at high risk for brain tumors (120).

Stewardesses in ships had an excess risk of thyroid cancer with two observed cases. Another group with an excess risk was matrons, for whom there were three observed cases. It is interesting that there was also an indication of an increased risk in partly related occupations such as self-employed and family workers in hotels and restaurants (RR 2.25, 95 % CI 0.3–8.1) and nurses and assistant nurses in hospitals (RR 1.49, 95 % CI 0.7–2.7). Although ionizing radiation is a well-established risk factor for thyroid cancer, no association with occupational exposure to radiation has been found (121).

Librarians form a small occupational group, and there was an excess risk of thyroid cancer in this group, there being 2 observed and 0.32 expected cases. It is, however, worth mentioning that there was one observed case of thyroid cancer among the male librarians, for whom 0.11 cases were expected.

### Pursuing new associations

The validity of new observations in a linked register may be questioned as the occupation is known only at one point in time, data on specific exposures are not available, data on potential confounding factors are not available, and tabulation of the data across many occupational groups may produce chance findings. Our screening method of searching for new associations should therefore be considered only as a first step in a hypothesis-generating procedure.

Several further steps should be considered. First, data should be tabulated for related occupations with the use of the original census codes. For example, the excess risk of primary liver cancer in skilled lithographers could be checked through a tabulation of the incidence of primary liver cancer for the self-employed, foremen,

and others in lithographing establishments. These groups were not included as separate entities among the 492 detailed occupational groups of our study.

Second, the consistency of an excess risk over time could be checked. The excess mortality from lung cancer among butchers in Denmark has thus been found both during the period 1970–1975 and during the period 1975–1980 (56).

Third, inspection of the original census and the Cancer Register forms might be considered in order to obtain information not provided by the codes. Women in laundry and dry-cleaning shops in Denmark have, for example, an excess risk of primary liver cancer (122), but it is not possible from the coded information to distinguish between laundries and dry-cleaning shops. Data protection rules do not, however, at present allow inspection of individual records.

Fourth, a literature search should be made for data concerning the same occupation in in-depth epidemiologic studies and in published data from other surveillance systems (123).

Fifth, the existence of linked registers in all the Nordic countries allow cross-national studies. An observed excess risk in one country can be checked by tabulation of the equivalent data from the other Nordic countries. Analyses have been made of lung cancer in occupational groups with potential exposure to silica dust (46) and of bladder cancer in hairdressers (47).

Sixth, the linked register also provides a framework for nested case-referent studies on specific etiologic factors suspected to be responsible for the observed excess risks. A case-referent study on lung cancer in butchers has been made in Sweden following this procedure (60).

The linked register thus provides a basis both for a search for new associations and for the initial follow-up of new associations.

## SUMMARY

### Data sources and creation of data files

The cohort of persons who were 20–64 years of age at the time of the 1970 census has been followed for cancer incidence for a ten-year period. The study was made by linkage of individual records from the 1970 census, the Central Population Register, death certificates, and cancer registrations. Data were included on individual characteristics recorded in the census on prevalent cancer cases at the time of the census and on deaths, emigrations, and incident cancer cases during the ten-year follow-up period.

The study includes a total of 2.8 million persons, of whom 2.0 million were economically active at the time of the 1970 census. A total of 115 000 incident

cancer cases were registered during the follow-up period, and 77 000 of these occurred in persons who were economically active in 1970.

The classifications used in the census included 218 codes for occupation and 245 codes for industry. The Cancer Registry data included 639 codes for diagnosis.

### Cancer incidence by social groups in Denmark

The cancer incidence was tabulated across 32 socioeconomic groups for 43 cancer sites among the men and 45 cancer sites among the women.

The study showed an almost twofold difference in the overall cancer incidence between the socioeconomic groups of the men. Self-employed farmers were at low risk (RR 0.68), and unskilled workers in shipping/fishing were at high risk (RR 1.28) when the cancer incidence among all economically active men was used for the comparison. The social pattern in cancer incidence correlated well with the pattern for cancer mortality among men. As a rough estimate, the cumulative incidence for all cancer among persons under 75 years of age could be reduced by 32 % if all Danish men had the cancer incidence of farmers. There was a five-fold or larger difference between the socioeconomic groups in the incidence for nine cancer sites. These nine cancer sites together represented 7 % of the cumulative incidence for all cancer. Estimated in a similar way, the cumulative incidence could be reduced by 44 % if all Danish men had the site-specific cancer incidence of the respective low-risk groups.

The overall cancer incidence among the women varied from a relative risk of 0.71 for unskilled workers in agriculture to a relative risk of 1.18 for self-employed women in other industries I (dentists, lawyers, etc) when the cancer incidence among all economically active women was used for the comparison. Both the men and the women in agriculture thus had a low risk of cancer. There was, however, a difference between the men and the women at the high-risk end of the scale, as self-employed and well-educated women were among the groups of women with a relatively high cancer incidence. These groups of women had an excess risk of breast cancer and of other skin cancers, whereas unskilled women had an excess risk of lung cancer. The cumulative incidence for all cancer among persons under 75 years of age could, with a rough estimate, be reduced by 25–28 % if all women were under the cancer risk recorded for women in agriculture.

### **Occupational groups at high risk of specific cancers in Denmark**

The cancer incidence was tabulated across 492 detailed occupational groups for 43 cancer sites among the men and across 447 detailed occupational groups for 45 cancer sites among the women.

The validity of the linked register was assessed through the inspection of the data on classic associations between occupational exposures and cancer sites.

The register showed an excess risk of lip cancer among farmers and fishermen, an excess risk of primary liver cancer among waiters and brewery workers, an excess risk of pleural mesothelioma among occupations with potential exposure to asbestos, and an excess risk of nasal cancer among furniture makers.

The use of the linked register as a library for the further elucidation of associations between occupations and cancers reported in the literature was illustrated through the use of examples. An excess risk of bladder cancer among hairdressers found in Geneva was also found in Denmark. A suspected risk of malignant melanoma among lithographers could not be found in Denmark. Leukemia was not elevated among the majority of farmers in Denmark, but there was an indication of an excess risk for a subgroup of farms. An excess risk of brain tumors has been observed among dentists and dental nurses in Sweden, but this observation could not be confirmed in Denmark.

The linked register can be used in the search for previously unknown associations between occupation and cancer. A table was set up to aid the identification of high-risk occupational groups. It included each cancer site in those detailed occupational groups for which “observed > (expected + expected<sup>1/2</sup>),” when the expected numbers were based on incidence rates for all economically active men or women, respectively. These tables allowed the identification of clusters of high-risk occupational groups with related work tasks.

Examples of such clusters among the men were laryngeal cancer in smiths, mechanics, foremen, and shop owners of engineering workshops, leukemia among men employed in banking and finance, and leukemia among some occupational groups engaged in animal handling. Other examples were primary liver cancer among lithographers, bookbinders, some typographers, and among ceramists and artists. A further example was an excess risk of kidney cancer among health care personnel.

Examples of clusters of high-risk occupational groups among the women are cancer of the tongue among seamstresses, and stomach cancer among women in leading administrative positions and female gardeners. Other examples were brain tumors among physiotherapists and physicians and thyroid cancer in some groups working in hotels or nursing.

A strategy was suggested for pursuing new associations observed in a linked register.

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