

Chapter 5

Links between occupations and cancer: the strengths and limitations of the NOCCA project

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1. The NOCCA project

Occupational or work-related causes of cancer are well known in many cases, (e.g. vinyl chloride, chromium, asbestos etc.), but in other cases identification proves to be difficult due to long latency periods and overlaps with lifestyle and environmental factors. One approach to overcoming these problems is presented by the Nordic Occupational Cancer Studies (NOCCA) project.

Geographically covering the Nordics, the NOCCA project and links cancer data from national cancer registries to censuses and occupational categories. The study is based on a monitoring of the whole working populations in these countries (see Table 1).

Table 1 NOCCA structure

Country	Census(es)	Persons	Cancers and occupations	Monitoring period
Denmark	1970	2.0 million	Cancers: 469,000 Occupations: 220	1971-2003
Finland	1970, 1980, 1990	3.5 million	Cancers: 489,000 Occupations: 330	1971-2005
Iceland	1980/81	0.1 million	Cancers: 15,000 Occupations: 290	1982-2004
Norway	1960, 1970, 1980	2.5 million	Cancers: 538,000 Occupations: 570	1961-2003
Sweden	1960, 1970, 1980, 1990	6.8 million	Cancers: 1,248,000 Occupations: 300	1961-2005
Total		15 million	Cancers: 2.8 million	1961-2005

The main NOCCA database covers a total of 15 million workers, while the number of cancer cases diagnosed under the latest available census was 2.8 million.

Census data in the Nordic countries include the occupation of each employed person at the time of the census, as coded according to national classifications. Information on each person's occupation was provided through free text in self-administered questionnaires. The NOCCA team established 54 occupational categories, some examples of which can be seen in the following table.

Table 2 Examples of occupational categories used by NOCCA

Category number	Occupation	Description
13	Clerical workers	Includes secretaries and clerical workers in banks and insurance companies, accounting and bookkeeping clerks, keyboard-operating clerks, and other types of office workers.
31	Electrical workers	Workers in this category fit, assemble, install, maintain and repair electrical and electronic equipment such as electrical motors, generators, instruments, signal transmitters and receivers, domestic appliances, switchgear and control apparatus. They install and service electrical wiring systems in homes, industrial plants, ships, motor vehicles and aircraft, and install and service electrical power transmission cables, telephone and telegraph lines and related equipment.
32	Woodworkers	Workers in this category prepare and treat wood, and make, assemble and repair constructions and products made of wood.
33	Painters and decorators	Painters prepare structural surfaces for painting and apply decorative and protective coatings to buildings, ships, motor vehicles and articles made of wood, metal, textiles and other materials. Decorators cover interior walls and ceilings.
34	Other construction workers	Includes workers in the building and construction industry who do not constitute separate occupational categories in this study. Included here are reinforced concreters, cement finishers, terrazzo workers, insulation specialists, glaziers, underwater workers, and other unspecified building and construction workers.
35	Bricklayers	Workers in this category erect and repair foundations, walls and complete structures of brick, stone and similar materials and cover and decorate walls, ceilings and floors of buildings with tiles and mosaic panels.
36	Printers and related workers	Workers in this category compose type, cast and engrave printing plates and operate printing presses to print texts and illustrations. Includes type setters, printers (not textile printers) and book binders.
37	Chemical process workers	Workers in this category distil, refine, cook, roast and grind chemical substances, prepare pulp for paper production, and make paper.

NOCCA aims to identify occupations associated with cancer risks, tracing exposure response associations between work-related factors and cancers. The method used by the team was to compare the observed number of cancer cases in each occupational group with the expected number of such cancer cases within the respective national population. These so-called standardised incidence ratios (SIRs) were calculated for the mentioned 54 occupational categories with regard to over 70 different cancers or subtypes of cancer.

To obtain more quantitative exposure estimates, the NOCCA team applied national Job-Exposure-Matrices (JEMs). These matrices allow occupation-specific exposure estimates, usually based on expert opinion and exemplary measurements in different studies. The first use of the NOCCA-JEM procedure concerned occupational exposure to tri- and tetrachloroethylene and the risk of NHL (non-Hodgkin's lymphoma) and cancers of the liver and kidney.

The following factors were included in NOCCA-JEMs (as of August 2013):

- chemicals: aliphatic and alicyclic hydrocarbon solvents, aromatic hydrocarbon solvents, asbestos, benzene, benzo[a]pyrene, chlorinated hydrocarbon solvents, chromium, formaldehyde, petrol, lead, methylene chloride, nickel, perchloroethylene, sulphur dioxide, toluene, 1,1,1-trichloroethane, trichloroethylene;
- process-generated chemical substances: animal dust, bitumen fumes, welding fumes, wood dust, crystalline silica, diesel exhaust fumes;
- non-chemical factors: ionising radiation, night work, perceived physical workload, ultraviolet radiation.

The JEM analysis allows possible occupational co-exposures (as confounders in research) to be taken into account, as well as lifestyle confounders (smoking, alcohol, obesity, physical exercise, parity, and so on) derived from other available datasets.

Pukkala and colleagues published detailed results of their analyses in 2009. The authors presented the observed number of cancer cases (Obs), and the relative level of the cancer incidence of 54 occupational categories, described by the standardised incidence ratio (SIR), for 48 cancers. The entire national study populations were used as reference rates (national incidence rates). A SIR above 1 means that workers in the respective occupational category are diagnosed more often with cancer than the related national population. If the observed cases are double the number of expected cases, the SIR equals 2 (Table 3). See example below.

Table 3 Example of NOCCA results

Occupational category	Denmark		Finland		Iceland		Norway		Sweden		Total	
	Obs	SIR	Obs	SIR	Obs	SIR	Obs	SIR	Obs	SIR	Obs	SIR
Domestic assistants	[0.23]	0.00	[0.88]	0.00	[0.02]	0.00	[1.05]	0.00	11	1.45	11	1.13
Waiters	67	1.54	7	0.63	[0.58]	0.00	84	1.51	62	1.17	220	1.34
Building caretakers	292	0.98	169	1.01	9	1.62	164	1.10	554	1.15	1.188	1.08
Chimney sweeps	20	2.71	15	1.25	-	-	23	1.50	46	1.36	104	1.52
Hairdressers	84	0.98	2	0.60	[0.82]	0.00	39	0.88	149	1.19	274	1.06

Extract from "Observed incidence of colon cancer among men in the Nordic countries and standardised incidence ratios 1961-2005, by country and occupational category".

Obs: observed cases

SIR: standardised incidence ratios

The SIRs of 1.34 for waiters and of 1.52 for chimney sweeps clearly indicate that these workers have a higher colon cancer risk.

In general, a number of expected associations were confirmed, for example mesothelioma among plumbers, seamen and mechanics, i.e. occupations with asbestos exposures; lip cancer among fishermen, gardeners and farmers engaged in outdoor work; nasal cancer among woodworkers (wood dust); and lung cancer among miners exposed to radon and

silica. Some of the interesting new findings of NOCCA that deserve further attention include cases of cancer of the tongue and vagina among women chemical process workers; melanoma and non-melanoma skin cancer, breast cancer (in both men and women) and ovarian cancer among printers; fallopian tube cancer among packers and hairdressers; penis cancer among automobile drivers; and thyroid cancer among female farmers.

Another conclusion drawn by the NOCCA team was that occupation-related social factors seem to be more important determinants of some cancer risks than the actual occupational ones. For example, they mentioned factors, such as life style changes related to longer education and decreasing physical activity, as well as the high risks of alcohol-related cancers among workers having easy access to alcoholic beverages in their work. In general, the team concluded that some 5% of all cancers both in males and in females are directly related to work, while about 35% in males and 16% in females are attributable to socio-economic factors.

The NOCCA study also provides information about the existing socioeconomic divide, meaning that workers in blue-collar, low-skilled occupations are more at risk, and about factors for which the link to occupations is difficult to establish, such as static/sedentary work, a risk factor for intestinal cancer.

The people behind NOCCA

The NOCCA project is carried out by a large group of epidemiologists, complemented by an equally large group of industrial hygienists from all Nordic countries. Some of the main scientists include:

- Eero Pukkala (general coordination of the project), Finnish Cancer Registry
- Jan Ivar Martinsen, Norwegian Cancer Registry
- Elsebeth Lynge, Copenhagen University (Denmark)
- Pär Sparèn, Karolinska Institute (Sweden)
- Laufey Tryggvadottir, Icelandic Cancer Registry
- Elisabete Weiderpass, Karolinska Institute (Sweden)
- Kristina Kjærheim, Norwegian Cancer Registry

2. Strengths and limitations

The pooled database from the Nordic countries presents several features making it a unique resource for research on occupational cancer:

- it covers all working-age people in five countries;
- monitoring after occupational exposures covers several decades;
- data on occupation (basis for exposure estimate) and cancer data are almost complete and of high quality;
- the proportion of working women is high;
- data on potential confounders such as smoking, parity and obesity can be obtained.

The large scale of NOCCA allows associations between a wide range of risk factors/occupations and cancer sites/cell types to be studied, including rare types, taking into account the wide range of exposures gained from different data sources as mentioned above. In this way NOCCA links cancer data with occupational categories and provides the opportunity to simultaneously evaluate cancer patterns by occupation and occupational patterns by cancer, an approach not otherwise possible, according to the NOCCA team coordinator Eero Pukkala.

NOCCA has proved to be useful for comparisons with findings from other areas: Japanese researchers identified a cluster of 11 cases of cholangio-carcinomas (cancer of the gall or bile duct) among 62 male offset colour printing workers at a plant in Osaka. NOCCA was used to clarify the question whether their findings could be generalised to the printing industry at large. The NOCCA analysis supported the view that the cancer risk extended beyond the specific company and beyond Japan. The researchers identified exposure to chlorinated solvents as a direct cause.

NOCCA identifies occupations at risk but does not necessarily pinpoint direct causes of occupational or work-related cancers. This can be overcome by adding occupation-specific exposure estimates of risk factors to the NOCCA-JEMs. However, it has to be noted that the JEM approach relies to a large extent on expert opinion and not on measurements and may therefore carry larger uncertainties. NOCCA studies may therefore need to be complemented by surveys such as Giscop93. Very much needed in this respect are also company exposure records, but this requires government action and strict enforcement.

In its monitoring, NOCCA assumes that a person will stay in the same occupation. However, in view of the effects of globalisation it seems unlikely that this will always correspond to the lifelong occupational history of a person. Yet the NOCCA team is convinced, referring to the results of special occupational cancer studies, that the risk-diluting effect of misclassification will be small.

For the purpose of NOCCA, workers who work part-time (less than 20 hours a week in one job) are excluded from the data. An EU-OSHA study highlighted this as a factor possibly contributing to the underassessment of women's exposures, as in Europe many women work part-time. In addition, more and more workers work in multiple jobs, and although the number of hours worked in each job may be low, their overall cumulative exposure should be assessed. Such contracting patterns are frequent in services jobs such as cleaning, and even increasingly in construction.

The combination of cancer registry and census data has produced a large pool of high-quality data for the Nordics. Combined with the long monitoring period this allows even rare cases of work-related cancers to be studied. However, it should be remembered that NOCCA only identifies occupations at risk, without necessarily detecting direct causes of work-related cancers.

References

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