A 24-year follow-up of malignancies in Sweden after the Chernobyl nuclear power plant accident in 1986

TONDEL Martin[1], WÅLINDER Robert[2], LAMPA Erik[2]

[1]*Occupational and Environmental Medicine, Department of Public Health and Community Medicine, The Sahlgrenska Academy, University of Gothenburg, Gothenburg, SWEDEN, martin.tondel@amm.gu.se*

[2]*Department of Occupational Medicine, University hospital/University of Uppsala, Uppsala, SWEDEN*

Abstract: A 24-year follow-up of total malignancies in Sweden after the Chernobyl nuclear power plant accident in 1986 shows a small increase in the incidence of malignancies when the average deposition of caesium-137 for each parish was used to classify the exposure.

Background: The accident at the Chernobyl nuclear power plant in Ukraine, USSR occurred on 26 April, 1986. Five percent out of the total 85 PBq released caesium-137 from the Chernobyl reactor was deposited in Sweden during the ensuing days, especially during the heavy rainfall on April 28-29, with an unequal distribution in the eastern coastal regions from Stockholm in the south to Umeå in the north [1]. The main contributors to the dose rate in the first weeks were short-lived nuclides replaced by the long-lived caesium-134 and caesium-137 [2]. Two studies in Sweden have shown a slight increase in total malignancies related to caesium-137 deposition after the Chernobyl accident. In the initial study the inhabitants in the 450 parishes in 7 counties in Northern Sweden were classified using an analogous map on the deposition of caesium-137 in these parishes, the excess relative risk (ERR) was calculated to 0.11 per 100 kBq/m^2 (95% Confidence Interval 0.03-0.20) [3]. In the second study a digital map was used instead to match each person's dwelling coordinate to the exposure of caesium-137 with a similar result of ERR 0.10 per 100 kBq/m^2 (95% CI 0.00-0.23) [4].

Methods: The population in nine out of Sweden's 21 counties was included in this 24-year follow-up study: Norrbotten, Västerbotten, Jämtland, Västernorrland, Gävleborg, Dalarna, Västmanland, Uppsala and Södermanland. These counties had the highest fallout of radionuclides in Sweden after the Chernobyl accident, but had also areas with no fallout. The total population was annually retrieved from the National Archives 1986-1992. Each individual was classified annually with their address to the parish. In all, 612 parishes and 2,183,212 individuals were included in the study. The average deposition of caesium-137 for each parish was given by the Swedish Radiation Safety Authority from the lowest average of 1 to the highest of 85 kBq/m^2 in May 1986. By assignment with the Swedish Radiation Safety Authority, the Geological Survey of Sweden had performed aerial gamma measurements over the whole of Sweden creating a grid of 200•200 meter of caesium-137 deposition. This digital map was used by the Swedish Radiation Safety Authority to calculate the parish average.

Using the annual address for the individuals each person could be followed over time. Taking into account both the half-life of caesium-137 of 30 years and if a person changed address a cumulative exposure estimate could be created in kBq•years/m^2 for 1986-1992. Cases of malignancies and deaths with date of

diagnosis were retrieved from the Swedish Cancer Registry for April, 28 1986 to December, 31 2009. If there was more than one malignant neoplasm registered for a person, we considered only the first one. Individuals with a malignancy before 28 April 1986 were excluded from the analyses. Incidence of malignancies was also calculated for the period January, 1 1980 to April, 27 1986, using the same classification of parishes and methods in order to investigate if there was a regional difference in the incidence already prior to the Chernobyl accident. All malignancies were coded according to the International Classification of Diseases (ICD), version 7, as continuously used by the Swedish Cancer Registry. A total of 201,201 incident cases of malignancies were observed during 49,155,576 person-years.

A Poisson regression model was applied, including total cases of malignancies, taking age as a continuous variable and sex as potential confounding factors. Exposure expressed as kBq•years/m^2 (see Figure below) was used as a continuous variable to study the exposure response relationship. All continuous variables were modeled using restricted cubic splines to account for potential non-linear relationships. The statistical model included age, cumulative exposure and sex together with sex•age and sex•cumulative exposure interaction terms to allow for different exposure-response relationships across different ages and sexes. All statistical analyses were performed using R version 2.13.0.

Results: The median exposure for caesium-137 was 226 kBq•years/m^2. Incidence of malignancies for men showed an average increase of about one case and for women about 0.5 case per 1,000 person-years between 5th to 95th percentile (table 1). The incidence of malignancies for men was partly influenced by a weak positive pre-Chernobyl trend over the parishes.

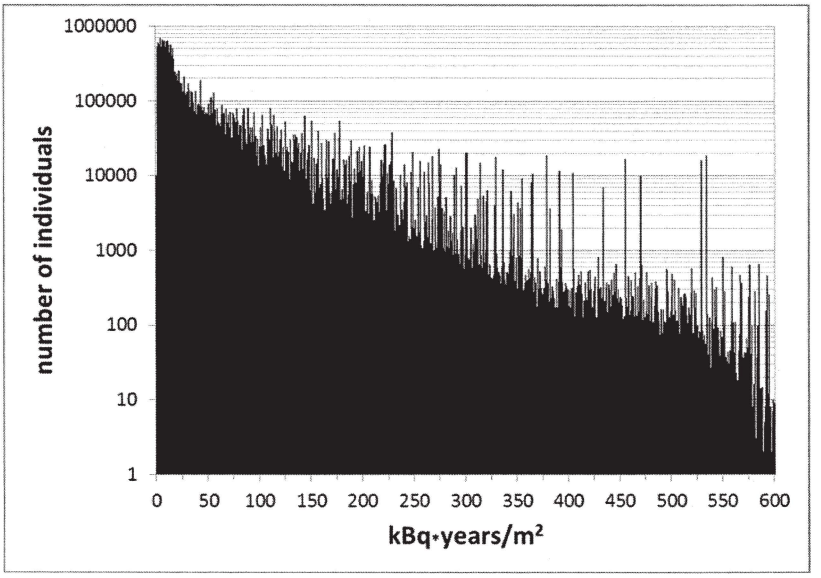

Table 1 Total malignancies April, 28 1986 to December, 31 2009

	percentile	Cs-137 kBq*years/m^2	Incidence per 1,000 person-years	95% confidence interval
Men	5th	21	3.31	3.28-3.35
	95th	524	4.43	4.26-4.61
Women	5th	21	2.58	2.55-2.61
	95th	524	3.10	2.97-3.24

Conclusion: Preliminary results from a 24-year follow-up study in Sweden after the Chernobyl nuclear power plant accident could indicate a slight overall increased incidence of total malignancies for cumulative exposure. Further analyses will focus on the exposure response relationship after improved dosimetry and separate analyses will be performed on sites with a known relationship to ionizing radiation e.g. leukaemia.

REFERENCES

1. Mattsson S, Moberg L. Fallout from Chernobyl and atmospheric nuclear weapons tests. Chernobyl in perspective. In: Moberg L, editor. The Chernobyl fallout in Sweden-results from a research programme on environmental radiology. Swedish Radiation Protection Institute, Stockholm, 1991, pp. 591-627.

2. Edvarson K. External doses in Sweden from the Chernobyl fallout. In: Moberg L, editor. The Chernobyl fallout in Sweden-results from a research programme on environmental radiology. Swedish Radiation Protection Institute, Stockholm, 1991, pp. 527-545.

3. Tondel M, Hjalmarsson P, Hardell L, Carlsson G, Axelson O. Increase of regional total cancer incidence in north Sweden due to the Chernobyl accident? Journal of Epidemiology and Community Health 2004;58:1011-6.

4. Tondel M, Lindgren P, Hjalmarsson P, Hardell L, Persson B. Increased incidence of malignancies in Sweden after the Chernobyl accident--a promoting effect? American Journal of Industrial Medicine 2006;49:159-68.