Estimation of the Risk of Radiation-induced Leukaemia among Young People in the Vicinity of the La Hague Reprocessing Plant : Results from the Nord-Cotentin Radioecological Study

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INTRODUCTION

A radioecological study (1) concerning the La-Hague nuclear reprocessing plant (Nord-Cotentin, France, see figure 1) has been performed by a Working Group composed of nuclear operators, authorities, French and international experts and members of environmental organisations and supported by the IPSN. The study aimed to reconstruct radiation doses to young people aged 0 to 24 years, living in the Beaumont-Hague area between 1978 and 1996, with a view to estimate the radiation-induced risk of leukaemia and compare that risk with the results of previous local epidemiological studies.

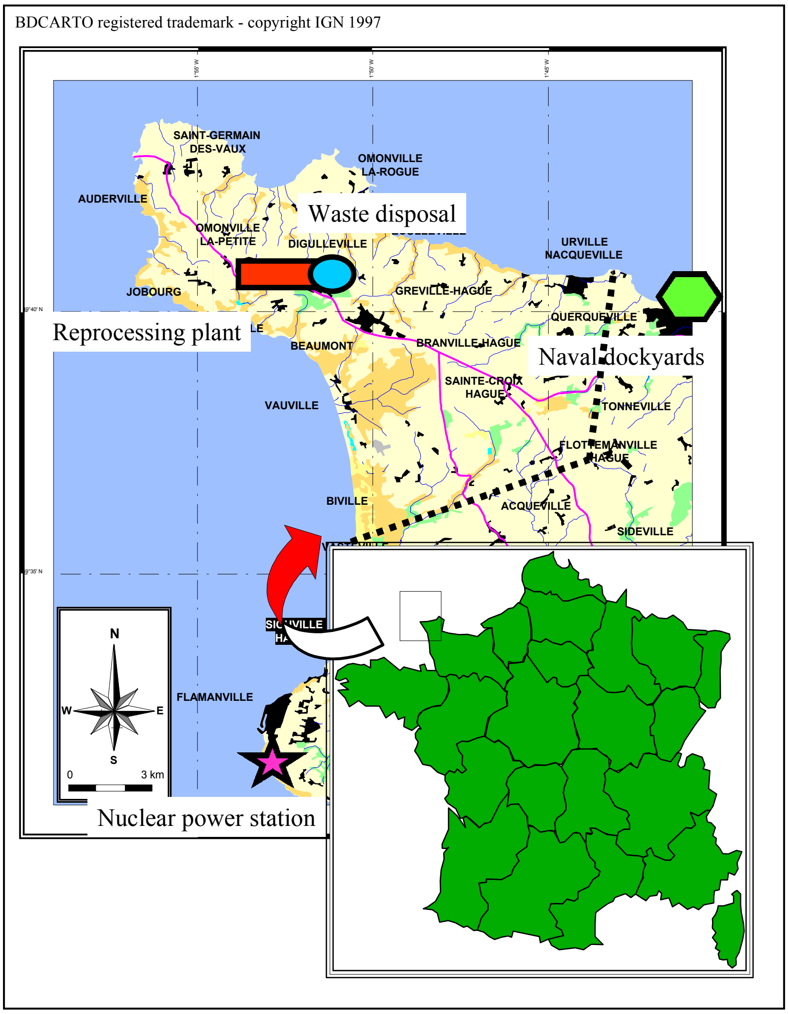

Figure 1 : The region concerned by the radioecological study

METHODOLOGY

A cluster of leukaemia, related to people aged 0 to 24 who have been living in the canton (a French administrative area) of Beaumont-Hague between 1978 and 1996, was suggested by previous epidemiological studies (2,3). In the frame of the radioecological study, the radiation-induced risk of leukaemia has been estimated for the same population (dark area of figure 2). But because each dose to the red bone marrow received in the past contributes to the individual risk between 1978 and 1996, doses have been calculated for each year between 1954 and 1996 and for five age groups (pale area of figure 2).

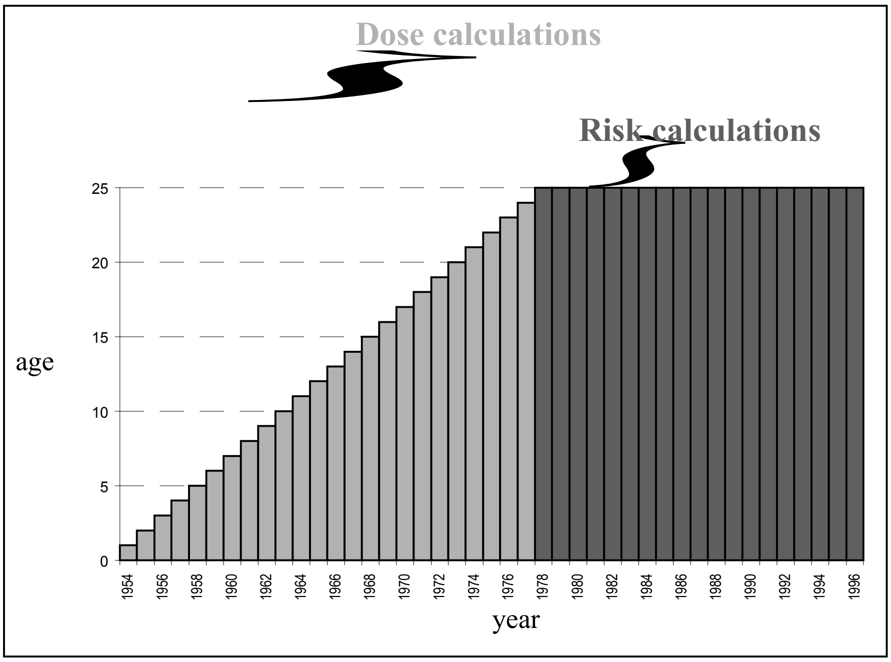

Figure 2 : Schematic diagram of the reconstructed cohort

The demographic reconstruction of the Beaumont-Hague cohort was based on the yearly birth rates data in each of the 19 cities of the canton. Each individual born in the canton was supposed to stay there until the age of 25 (or up to 1996 if this age is not reached). Mortality rates came from national data because local ones are not available. Furthermore, it was necessary to take into account people's migrations in the canton because the operator COGEMA built one of its reprocessing unit during the 1978-1996 period and many workers arrived with their family into the canton to participate in the construction. The scholarship data were used to reconstitute the demographic variations of the cohort.

Calculations of doses and risk were performed as presented on figure 3.

The concentrations of the radionuclides in the environment which are the inputs for the dose calculation result from the combination of two approaches : the modelling of the transfer of the radionuclides released in the environment (over 80 radionuclides) and the use of environmental measurements. Four nuclear installations of the Nord-Cotentin area have been considered : the COGEMA-La Hague reprocessing plant, the EDF-Flamanville nuclear power plant, the ANDRA waste disposal and the French Marine naval dockyards at Cherbourg. The exposure pathways retained for the modelling were :

external exposure	by the plume by ground depositions by the sand of the beaches by the seawater during bathing
internal exposure	by inhalation of the plume, the resuspended particles and the seaspray by ingestion of seafood and terrestrial food contaminated by the atmospheric and marine releases, the seaspray and the spreading of algae by ingestion of sand, ground and seawater.

The two most important accidental releases were taken into account by specific models : the breaking of the marine discharge pipe of COGEMA in 1979-1980 and the fire of a storage unit of COGEMA in 1981.
The dose modelling used the habits data of the local population (ingestion rates, occupancies). The difficulty was to define the most realistic life habits for the cohort in the past. Results from existing local surveys were used as

often as possible but the working group had to make hypotheses when no local data were available. The values of dose coefficients to the red bone marrow were extracted from (4). These values were interpolated to calculate the equivalent dose delivered each year to the red bone marrow.

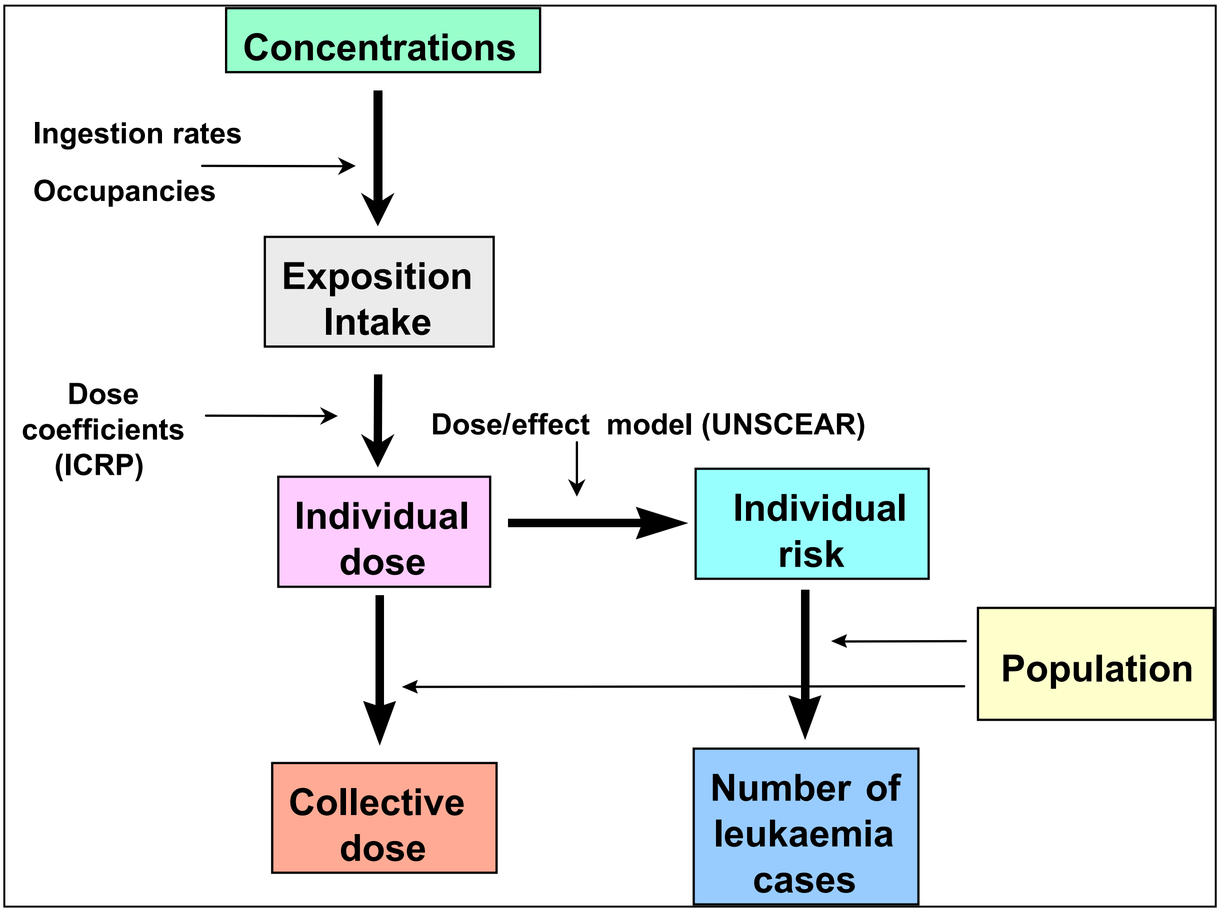

Figure 3 : Methodology to assess doses and risk

The other sources of exposure (natural, medical, the Chernobyl accident and nuclear arms atmospheric testing) were studied more globally because few local data concerning natural and medical exposures were available. The aim was only to allow a comparison with the doses due to the local nuclear installations.

The number of radiation-induced leukaemia was calculated using two models recommended by international groups of experts : the BEIR V model (5) and the UNSCEAR 1994 model (6). The UNSCEAR model was preferred because its application does not require a background reference of leukaemia incidence, which does not exist for the whole period in France.

RESULTS

The reconstructed Beaumont-Hague cohort includes 6656 young people born between 1954 and 1996, who inhabited the canton for at least one year between 1978 and 1996 before the age of 25. The number of person-years between 1978 and 1996 is 69308. Contributions to the collective dose calculated for the cohort from all sources of exposure (local nuclear installations : routine and accidental discharges from the four installations of the Nord-Cotentin Peninsula, natural exposure, medical exposure and Chernobyl and nuclear arm testing) appear in table 1.

Table 1 : Collective doses and doses per person.year to the red bone marrow for the reconstructed Beaumont-Hague cohort from all sources of exposure

	Collective dose estimated for the cohort in man.Sv	Collective dose estimated for the cohort in % of the total	Period of exposure (person.year)	Dose per person.year in µSv
Routine discharges	*0.30*	*0.10%*	*1966-1996 (94 300)*	*3*
Breaking of the marine discharge pipe	*0.04*	*0.01%*	-	-
Fire of the storage unit	*0.14*	*0.04%*	-	-
Total due to local installations	0.48	0.15%	1966-1996 (94 300)	5
Natural exposure	241	74%	1954-1996 (103 200)	2335
Medical exposure	76	24%	1954-1996 (103 200)	740
Chernobyl and nuclear arm testing exposure	5	2%	1954-1996 (103 200)	48
Total	**322**			**3128**

The dose is calculated for the red bone marrow because it is the organ of interest for leukaemia. The total collective dose to the red bone marrow due to local nuclear installations is 0.5 man.Sv. For the sake of comparison, the collective dose due to all sources of exposure is 241 man.Sv (Figure 4). Routine and accidental releases from nuclear installations of Nord-Cotentin contribute for less than 0.2% to the total exposure.

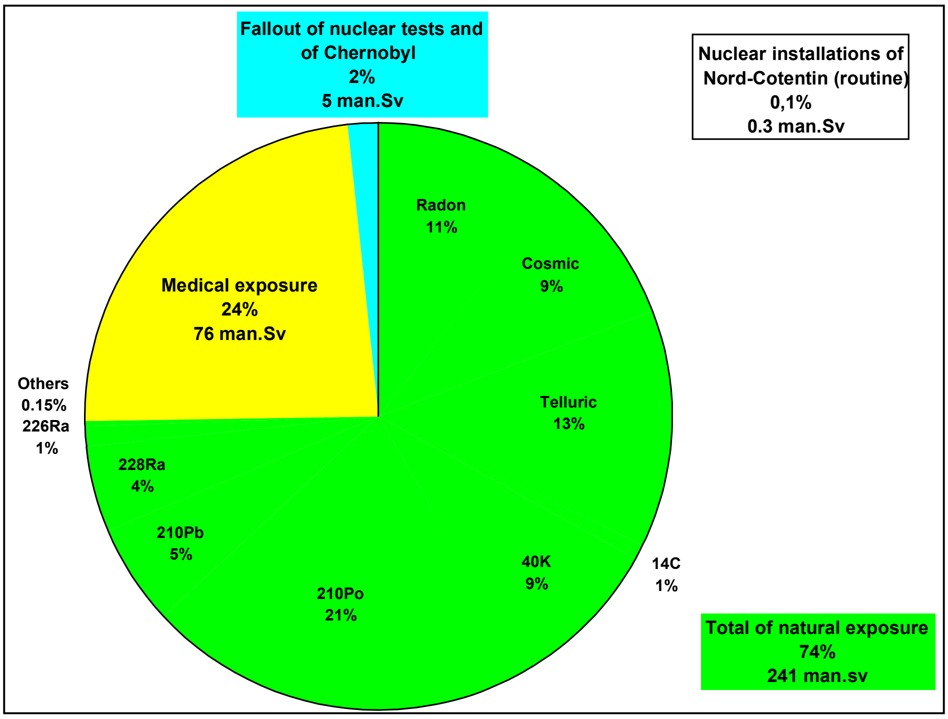

Figure 4 : Collective dose to the red bone marrow due to all sources of exposure

The total number of leukaemia attributable to routine discharges from nuclear installations of the Nord-Cotentin is estimated at 0.0009 for the period 1978-1996. The number of leukaemia added by the break of the pipe and the fire are respectively 0.0001 and 0.0004. The total number of leukaemia due to all sources of exposure is estimated at 0.835. 74% are due to natural exposures, 24% to medical ones and 2% to the Chernobyl accident and nuclear arm testing.

Individual dose and risk were also assessed for three scenarios based on life habit data suggested by a previous epidemiological study (7), and susceptible to lead to greater exposure : a high consumption of seafood by the young people, a long time spent on local beaches by the young people or by the mothers during their pregnancy. Results show that even a very intensive frequentation of local beaches by children or mothers (80 min per day) does not increase significantly the individual radiation-induced risk of leukaemia. The radiation-induced risk of leukaemia for a young individual who eats a lot of local seafood (up to 500 g per day) is increased by a factor of about 2, but this increase is essentially due to the ingestion of natural radionuclides contained in seafood, such as ^{210}Po.

CONCLUSION

The estimated number of radiation-induced leukaemia cases attributable to local nuclear facilities, based on the reconstruction of exposures to radiation in the Nord-Cotentin, is very low when compared to the incidence of leukaemia expected or observed on the same period by epidemiologists (2 and 4 cases, respectively). Specific habits do not lead to important increase in the risk of leukaemia due to releases from local nuclear facilities. The result from this risk assessment process can be considered as a best estimate, but the uncertainty around this estimation has not been quantified yet.

Two main difficulties had to be solved by the Working Group. First the retrospective feature of the study resulted in a paucity of detailed information on past data and as a consequence, many hypotheses had to be made. Second, the search for consensus on various hypotheses in a group composed of operators, authorities and members of environmental organisations was a difficult task but precisely that composition allowed the Working Group to perform a fully contradictory assessment. However some members of the group had reservations about the conclusions as far as the above mentioned uncertainty study is not performed.

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