

## The Health of the Offspring of Sellafield Employees

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### Background

In 1990 Gardner et al [5,6] suggested that paternal preconceptional exposure to external ionizing radiation at the nuclear installation, Sellafield, could be a possible explanation for the excess of childhood leukaemia and lymphoma which had been observed in the adjacent village of Seascale. One of the effects of the Gardner report was to shift the search for the cause of the Seascale excess from 'environmental' to 'individual' factors and in order to investigate fully the possible association between individual preconceptional radiation exposures and the health of offspring, a unique database has been established for Cumbria. The database includes information on all Cumbrian born children of the 28,184 men and women employed at the Sellafield nuclear installation, at any time from 1947 to the end of 1993.

### Database construction

The Office for National Statistics (formerly Office of Population Censuses and 293,271 children born in Cumbria since 1950. The information from the birth certificates, (including parents names and occupation) was entered into a database [8]. This database, which was constructed using 4th Dimension [1] was then linked to the Sellafield personnel database and hence the 20,491 Cumbrian born offspring of the Sellafield workforce were identified. This identification and linkage process was also conducted for more than 4,000 stillbirths in Cumbria over the time of the study. A validation exercise to investigate the completeness and accuracy of the parent-child link-

age procedure was conducted and showed that the linkage successfully identified over 98% of the relevant child group [7].

Through Regional and National Cancer Registries and the National Health Service Central Registry, all children within the cohort who have developed cancer or died have been identified. All cancer diagnoses have undergone pathological review and all causes of death have been reviewed and coded to ICD-9 [9,10] Post mortem and medical records have been reviewed where possible. Thus transgenerational effects of radiation exposure can be investigated by exploration of a wide range of serious health outcomes rather than merely focusing on childhood leukaemia which would not necessarily be the most likely outcome of such exposures.

The occupational radiation doses (both internal and external) to mothers and fathers identified within the Sellafield workforce have been obtained, including exposure to specific radionuclides and hence preconceptional radiation exposures were calculated.

It has been possible to identify

- a complete cohort of Cumbrian born children of the Sellafield Workforce
- the children with significant health problems within this group
- the preconceptional radiation doses associated with each birth.

An overview of the database is given in Figure 1.

### Studies of the Database

The database has been used to assess the transgenerational effects of parental radiation exposure on the health of children

using geographical, case-control and cohort study methodologies.

### *Geographical Studies*

The geographical distribution of the paternal preconceptional radiation dose associated with births in the Cumbrian cohort to fathers employed at Sellafield was explored using a geographical information system ARC/INFO [3,4]. It was known that the only excess of cases of childhood leukaemia in Cumbria associated with paternal preconceptional irradiation (ppi) was in Seascale [5]. Hence, if Gardner's hypothesis of the role of ppi in leukaemogenesis was correct, a substantial heterogeneity in the distribution of the collective ppi would be anticipated with a substantial excess dose associated with Seascale where the excess cases were known to be concentrated. The geographical distribution of ppi showed no such heterogeneity [7], and indeed the mean dose associated with Seascale births to Sellafield employees was lower than that elsewhere in West Cumbria being 49.1 mSv per birth following a paternal preconceptional exposure in Seascale and 60 mSv per birth for the remainder of West Cumbria. Thus, this study did not support the Gardner hypothesis of leukaemogenesis. Studies of the geographical distribution of the health outcome data are ongoing, as is an exploration of the geographical distribution of paternal preconceptional exposure to internal radionuclides.

### *Cohort Studies*

Cohort studies relating health outcome data (stillbirth, cancer, death by specific cause eg congenital anomaly) to paternal and maternal radiation exposures are possible using the database which allows the health of the offspring of the Sellafield workforce to be placed within the context of the whole of the Cumbrian born population.

Logistic regression analysis has been used to explore the relationship between paternal

preconceptional external radiation exposure and the sex ratio (number of boys/number of girls) of offspring [2].

Overall the Sellafield workforce had a higher sex ratio (1.094, 95% CI: 1.060, 1.128), than the remaining Cumbrian births (1.055, 95% CI: 1.046, 1.063), though this excess was partially explained by the observation that the workforce fathers were on average younger than other fathers in Cumbria. The children of the 345 fathers who had radiation exposures greater 10 mSv in the 90 days prior to conception had a higher sex ratio (1.396, 95% CI 1.127, 1.729). However, this result was not robust to the effects of dose group misclassification which arose because the majority of the 90 day doses were derived from apportioning doses recorded in annual dose summaries and not directly from monthly film badge records.

Cohort studies of the risk of cancer, stillbirth and death in the children of parents occupationally exposed to radiation at Sellafield are ongoing.

### *Case-control Studies*

Nested case control studies, in which occupational exposures can be ascertained in much more detail than is possible for the entire cohort are also underway to explore the risk of adverse health outcome in children of exposed parents.

### *Summary*

We have constructed a comprehensive database for Cumbria which allows the health of children born to the Sellafield workforce to be investigated within the context of a complete cohort study. In addition we will be able to use the database for the exploration of other environmental, geographical, temporal and occupational factors affecting the health of all children in Cumbria.

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**Acknowledgments**

We are grateful to United Kingdom Coordinating Committee on Cancer Research, Westlakes Research Institute and North of England's Children's Cancer Research Unit for funding the project and associated staff. We thank all the staff involved at BNFL, Westlakes Research Institute and Newcastle University for their help and support. We also thank OPCS, NHS-CR and all the cancer registries for their cooperation.

**Figure 1: Cumbria Database**

