Nuclear pollution, childhood leukaemia, retinoblastoma and brain tumours in Gwynedd and Anglesey Wards near the Menai Straits, North Wales 2000-2003

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1. Background

The Irish State previously funded Green Audit to study cancer in North Wales using Wales Cancer Registry small area data covering the period 1974-1990 [Busby, 2000] in order to examine the possible effects of nuclear pollution from Sellafield on the coast of Ireland. The reports drew attention to the discovery in the data of a sea-coast effect in cancer and leukaemia in adults and also in children. This effect showed itself as a sharp rise in risk in small areas close to the coast in north Wales, particularly in towns near coastal areas where there was intertidal sediment contaminated with radioactive material from Sellafield or other historical sources e.g. weapons fallout or Chernobyl fallout after 1986. As well as adults, the findings showed high relative risks for cancer in children, mainly brain tumours and leukaemia. These were highest in 0-4 year olds living within the coastal towns near the Menai Strait in particular Bangor and Caernarfon toward the latter half of the period studied, 1982-1990. Table 1 shows the numbers and risks for leukaemia.

Table 1 Areas of Residence with more than one case and also high (>3) relative risk of leukaemia in the 0-4 age group in the north Wales area from 1982-1990 (Wales Cancer Registry validated data).

AOR	Number of cases	Relative Risk (a)
71CC Colwyn Bay	3	5.6
74CA Bangor	3	11.2
74CE Caernarfon	2	8.1

(a) based on England and Wales, 1979

Leukaemia has been connected with radiation exposure since the original discovery of high rates in those exposed to the A-bomb radiation at Hiroshima and Nagasaki. In 1984, childhood leukaemia became associated with exposure to material from nuclear sites following the discovery of a cluster of cases in Seascale near Sellafield. It should be noted, in what follows, that the number of cases involved in this rare condition is very small. In Seascale and the coastal villages (Drigg, Carleton, Bootle, Waberthwaite and Muncaster) there were 2 deaths from leukaemia within 4 deaths of all cancers in the 0-14 year age group in the 16 years between 1963 and 1982. There were 9 cases (incidence) of childhood cancer in Seascale and the coastal villages in the same period (Beral et al, 1993). This area has been extensively studied and the effect of Sellafield radiation exposures have been hotly disputed since the 1983 discovery of the elevated rates. Since then also there have been reports of similar excesses from areas near the other two European nuclear reprocessing plants, Dounreay in Scotland and La Hague in France. Leukaemia clusters have also been reported from areas near many other nuclear sites, particularly those where contaminated river, estuary or sea sediment is involved, or particles of radioactive material are dispersed to the atmosphere [ECRR2003].

The effect in Wales is not restricted to leukaemia. The WCR data showed risks for brain tumours in children 0-4 of RR= 11 in Bangor (2 cases) and RR=14 in Llandudno (3 cases), RR= 10 in Prestatyn (2 cases) in the period 1974 to 1989. In the coastal strip of mean distance from the sea of 0.8km the overall risk in 16 AORs was RR=3.0 with 12 cases (4.04 expected), falling sharply to RR=1.6 in the next zone from the sea from 0.9 to 2km.

The explanation given by Green Audit (GA) was that sea to land transfer of radioactive particles followed by inhalation represented a risk to those living in the 0-1km coastal strip since the particles could be translocated from the lung to the lymphatic system resulting in leukaemia and other cancers and also producing germ cell damage and foetal damage *in utero* leading to effects in children.

The cancer findings were based on data supplied by the Wales Cancer Registry (WCR) in 1995. However, immediately after the data were released to Green Audit, WCR was suddenly closed and its personnel dispersed. The computer files given to GA were wiped from the mainframe computer. GA obtained a second copy of the data from the Statistical Directorate of the Welsh Office in 1996. In 1997, the cancer registration system was taken over by a new independent agency, the Wales Cancer Intelligence and Surveillance Unit (WCISU). Their Director, Dr John Steward, denied the existence of any excess cancer or leukaemia risk in children in North Wales and attacked the Green Audit report following the BBC Cymru TV documentary *Sea of Troubles* broadcast in February 1999. Steward made representations to the Committee on Medical Aspects of Radiation in the Environment who had been asked by the Welsh Assembly to comment. COMARE accepted Stewards position despite many serious problems with the way in which his data could be shown to differ from the WCR data. Steward later published new data in which 15% of the cancers in children aged 0-4 had been removed from the entire WCR database without explanation. It became clear that these cases were those that had contributed to the coastal effect. However, WCR had themselves, in 1994, already drawn attention [WCR 1994] to apparently high levels of childhood cancer in North Wales and in a meeting with Green Audit and The Low Level Radiation Campaign in 1995 had agreed that these figures had been validated by the Childhood Cancer Research Group in Oxford. CCRG has since denied this and stated in public that the discrepancy between the WCR and WCISU numbers arises out of misclassification of adults as children. But curiously, this effect appears to be specific to the coastal areas where the risks were apparently high. The matter has been one of dispute and contention ever since, and is presently part of the deliberations of the new Committee Examining Radiation Risks from Internal Emitters (CERRIE). Meanwhile, Green Audit has been attacked by COMARE, by the nuclear industry, and by the Welsh Assembly for refusing to concede that the new data created by WCISU represents the real picture and to withdraw its position on the childhood cancer and leukaemias in North Wales. Green Audit, on its part, has continued with epidemiology of areas close to the sea and estuaries contaminated with radioactive material and consistently found the sea-coast effect in cancer and leukaemia. Such an effect in estuaries was, in any case, originally reported in the literature by Alexander et al in 1990.

Since cancer registries no longer provide small area data, the truth of the matter can no longer be tested using official data that can be trusted. People, however, will only stand so much. It is therefore very welcome that relevant information has been independently gathered by HTV researchers as a result of interviews and snowball sampling carried out in North Wales. The data obtained in this manner is accurate and believable. The children's names, their illness and where they lived are largely known. We can therefore re-examine the position and see if there is indeed a problem with cancer and leukaemia in children in the coastal area of North Wales.

2. The Data

The data is from various confidential sources and is collected together below in Table 2 and 3. Table 2 has the cases from North West Wales and Table 3 has some data on deaths from various sources with occurred in the last 8 years. It is assumed that these cases and deaths are not the entire number, just those which have been obtained by interviews among those parents and carers of some of the children listed. They do however provide a baseline for estimating the risks and examining the situation.

Table 2 Cancer cases from interviews in North West Wales (from snowball interviews by HTV reporter)

Name	**sex**	**Born**	**Diagnosed**	**Age at diag**	**Area** **A = Anglesey**	**Cancer**
10	f	00	03	2	LlanfairPG (A)	ALL
11	m	86	02	15	Boddffordd (A)	Hodgkins Lym.
12	m	99	00	1	Beaumaris (A)	ALL
13	f	90	93	3	Bermo (Tywyn)	Brain
14	m	90	03	13	Amlwch (A)	NHL
15	m	99	02	3	Caernarfon, Waunfawr	ALL
16	f	87	03	15	Menai Br (A)	Brain
17	f	99	03	3	Caernarfon	Retinoblastoma
18	m	88	02	14	Valley (A)	Brain
19	f	98	00	2	Caernarfon	ALL
20	f	87	01	14	Llandegfan (A)	Hodgkins Lym.
21	f	87	99	12	Criccieth	ALL
22	m	95	99	4	Amlwch (A)	AML
23	m	85	01	14	Gaerwen (A)	Brain
24	f	98	99	1	Beaumaris (A)	Brain
25	m	99	03	4	Caernarfon	ALL
26	m	90	98	8	Criccieth	ALL
27	f	87	99	12	Llangefni (A)	Ovary
28	m	90	02	11	Treaddur (A)	ALL
29	m	98	02	4	Deiniolen	ALL
30	m	89	02	13	Llanllechid	ALL
31	f	00	03	3	Aberdaron	Brain
32	m	89	91	2	Criccieth	Brain
33	f	84	01	6	Caernarfon	Brain
34	m	88	96	8	Caernarfon	Brain
35	f	98	02	4	Caernarfon	Brain neuroblastoma

Note: ALL = Acute lymphoblastic leukaemia, AML = Acute myeloid leukaemia; NHL = non Hodgkin lymphoma

Table 3 Cancer deaths in children 0-14 in North Wales since 1996 according to interviews with families and friends.

Name	**Age at diagnosis**	**Area, Clwyd G = Gwynedd**	**Cancer**
101		Rhiwlas, G	Skin
102		Mold	ALL
103		Wrexham	ALL
104		Wrexham	Brain
105		Abersoch, G	Brain
106		Caernarfon, (Penygroes) G	Brain
107		Caernarfon	Spinal
108		Moelfre	Ewings sarcoma
109		Amlwch, Anglesey	Ewings sarcoma
110		Llandudno	Brain
111		Colwyn Bay	Brain
112		Mold	Ovarian
113		Caernarfon	Brain (neuroblastoma)
114		Holyhead	Wilms
115		Valley Anglesey	ALL
116		Rhyl	AML
117		Connahs Quay	Brain
118		Bangor (Tregarth), G	ALL
119		Wrexham	Wilms
120		Bodorgan, Anglesey	ALL
121		Wrexham	Brain
122		Halkyn	AML + retinoblastoma
123		Rhyl	AML
124		Wrexham	Brain
125		Wrexham (Penyffordd)	Ovarian
126		Wrexham	Brain
127	9	Dee estuary	ALL
128	14	Wrexham	?
129	8 d.1998	Bethesda	ALL
130	12 d.2000	Holyhead	ALL
131	13 d. 2000	Queensferry	ALL
132	3 d.1999	Bethesda	Brain NPS
133	7 d. 1999	Connahs Quay	ALL
134	12 d. 1999	Connahs Quay	AML
135	6 d. 2000	Llanfellech, Anglesey	Stomach
136	14 d 2001	Bangor, G	Neuroblastoma
137	14 d.2001	Caernarfon, G	Spine
138	Alive	Wrexham	Retinoblastoma

3. Childhood leukaemia in Caernarfon and in wards near the Menai Strait.

The results of the GA study in 2000 drew attention to increased cancer risks near the Menai Strait, particularly near Bangor and Caernarfon. The Strait and especially its northern entrance has fine intertidal sediment significantly contaminated with plutonium and other radioactive materials from Sellafield. It is around the Menai, that high risks would be expected on the basis of the earlier study. Accordingly, we have examined childhood leukaemia 0-4 in (a) Caernarfon and (b) all the wards which are either in contact with the sea or have more than half of their area within 10km of the coast from the northern to the southern parts of the Menai strait. We have compared the numbers expected on the basis of the 2001 census ward populations with those expected on the basis of England and Wales rates for 1997, the latest year for which such rates are available. We have looked at the period 2000-2003 since this is the most current period and would involve the least leakage of cases due to memory loss effects on the part of those interviewed.

3.1 Caernarfon

Table 4 Caernarfon wards, 2001 populations and expected numbers of cases of leukaemia in children aged o-4.

All leukaemias in children 0-4 (rate England and Wales, 0.000067)

Wards	**Population 0-4**	**Expected 0-4**
Cadnant	157	0.01052
Menai	94	0.0063
Peblig	158	0.0106
Waunfawr	119	0.008
Caernarfon all per year		0.0354

In the three years 2000-2003, there should have been 3 times this total, i.e. 0.106 cases of leukaemia, but from Table 2 it is clear that there were 3 cases. This gives us a relative risk of 28 ($p<0.00000$). But is this a random cluster? Well first there was a high rate of child leukaemia in the WCR data from 1992-90, so this is an on-going affair. Second, we can look at the larger area around the Menai to see if it is affected. We could also examine the coast and the coastal wards of Anglesey. However, the strongest evidence that this is an environmental effect is that there is also a large excess risk of brain tumours in children in the same town (see below).

3.2 The Menai wards in Gwynedd and Anglesey.

Wards which either have some coastal proximity or have areas mainly within 10km of the Menai Strait were selected to see if such proximity carried excess leukaemia risk in children aged 0-4 over the period 2000-2003. Table 5 lists these wards and their 0-4 populations at the 2001 census. In the case of wards which changed between the 1991 and 2001 census, the 1991 populations were used to calculate the expected number of leukaemia cases. These ward populations are given in italics.

From Table 2 there were 6 cases in this area in the period 2000 to 2003, giving a relative risk of 7.8 (p = 0.0005). If we exclude the Caernarfon cases and wards, then there were 3 cases with 0.66 expected, a relative risk of 4.5 (p= 0.02). These findings suggest that this is not a random cluster in Caernarfon but a general environmental effect centred on this area of coast, and a continuation of the coastal effect identified in Busby 2000.

Table 5 Menai wards used to examine risk of proximity to the coast with expected annual number of cases based on England and Wales 1997 rates. Wards with either a coastal proximity or largely within 10km of the coast.

Ward	**1991 ID**	**Pop 0-4 persons (2001)**	**Expected leukaemia**
Bethel	SZFA	100	0.0067
Bontnewydd	SZFB	63	0.0048
Cadnant	SZFC	157	0.011
Deiniol	SZFD	41	0.0027
Deiniolen	SZFE	149	0.01
Dewi	SZFF	101	0.0068
Garth	SZFG	27	0.0018
Gerlan	SZFH	181	0.012
Glyder	SZFJ	90	0.006
Hendre	SZFK	93	0.006
Hirael	SZFL	70	0.0047
Llandigai	SZFP	*176*	0.0118
Llanllechid/Aber	SZFQ	*77*	0.0051
Llanrug	SZFR	145	0.0097
Llanwnda	SZFS	123	0.008
Marchog	SZFT	*114*	0.0076
Menai Bangor	SZFU	42	0.0028
Menai Caernarfon	SZFW	94	0.0063
Ogwen	SZFX	147	0.0098
Peblig	SZFY	158	0.0106
Penisarwaun	SZFZ	114	0.0076
Pentir	SZGA	159	0.0106
Rachub	SZGC	*98*	0.0066
Seiont	SZGD	218	0.0146
Waunfawr	SZGF	119	0.008
Y Felinheli	SZGG	127	0.0085
Beaumaris	TCFC	78	0.0052
Cadnant	TCFH	40	0.0027
Cwm Cadnant	TCFK	84	0.0056
Llanfair Pwll	TCFU	152	0.01
Llanfihangel ym	TCFX	121	0.008
Llanidan	TCFZ	96	0.0064
Rhosyr	TCGK	128	0.0086
Tysilio	TCGN	134	0.0089
All wards		3824	0.256

4. Brain and spinal tumours in children 0-14 in the Menai area 1996-2000

The high rates of brain and spinal tumours in children in the north Wales area found in the 2000 GA report continues in the data obtained by HTV.

4.1 Caernarfon

The 1991 census 0-14 population of the four Caernarfon wards are given in Table 6 and the cases in Table 7. The 0-15 year populations can be obtained by linear interpolation.

Table 6. 1991 census populations 0-14 in Caernarfon wards

Ward	**0-4**	**5-9**	**10-14**	**0-14**
Waunfawr	110	104	95	309
Cadnant	93	100	114	307
Menai C	128	128	111	367
Peblig	277	236	159	672
Total all wards				1655

In Caernarfon, in the 8 years from 1996 to 2003 there would have been expected 0.28 cases on the basis of England and Wales national rates in this age group. However, there were 5 cases, representing a relative risk RR = 17.8 ($p < 0.00001$).

4.2 Menai wards

As with the leukemias, the situation is much the same for the brain tumours in the Menai wards, Table 8 showing the expected and observed values of risk.

Table 7 Brain and spinal tumours in the Menai wards

Name	**Diag/death**	**age**	**area**	**Cancer**
201	1999	3	Bethesda	Brain
202	2001	14	Caernarfon	Spine
203	2003	15	Menai Bridge	Brain
204	2001	14	Gaerwen	Brain
205	1999	1	Beaumaris	Brain
206	2001	6	Caernarfon	Brain
207	>1996	8	Caernarfon	Brain
208	>1996	?	Caernarfon	Brain
209	2002	4	Caernarfon	Brain (neuroblastoma)

Table 8 Relative Risks brain and spinal tumours in 0-15year olds, Menai area.

Period	Expected	Observed	RR	p-value
1996-2003	2.1	9	4.3	0.0003
1999-2003	1.3	7	5.4	0.0004

It is clear that the problem with brain tumours in children identified in the 2000 GA study continues, and that the denials by WCISU and the CCRG of the existence of the effect cannot be accepted in the face of the existence of these children.

5. Retinoblastoma.

This rare cancer has been well characterised as a genetic disease and its genetic locus is known but the illness has also been shown to occur with a high frequency (> 20-fold) in the offspring of those living near or working at Sellafield.

There were 6 cases in the data, two in Conwy, both under ten years old, and one in Caernarfon, XXXX, born in 1999 and diagnosed in 2003. On Anglesey there are three cases, all teenagers. The tables in this report refer to only one of these cases.

The relative risks (RR) are uncertain because we do not have the dates of diagnosis. Here we have taken a background annual rate of 0.37 per 100,000 (we have taken the US SEER rate, as we do not presently have the UK rate).

For Anglesey, if we assume (rather generously) that the cases have been diagnosed over a ten year period then in the population of 11,129 0 - 14 year olds the three cases give a relative risk of 7.5.

If we assume a five year period the three cases give a relative risk of 15.

For the whole of Gwynedd if we assume that they have been diagnosed over a ten year period then in the population of 33,797 0 - 14 year olds the six cases give a relative risk of 4.8. If we assume a five year period the six cases give a relative risk of 9.6.

Statistical significance is high. For the Gwynedd results the P value over the ten year period is 0.0015; over the five years P value = 0.00001.

Taken with the high rates of childhood leukaemia, the existence of the retinoblastoma is of interest since the effect appears to be located in the same area as the leukaemias, suggesting a common origin.

6. Discussion

The information obtained by the HTV researcher was largely from the area around the Menai Strait. The number of cases reported from other areas of Gwynedd and the former county of Clwyd do not represent a significantly high level of childhood cancer, and little can be said about the general levels in the whole of North Wales since it is fairly likely that only a fraction of the total number of cases over the eight years covered by the anecdotal data have been identified from the interviews.

There is some further evidence which supports the view that there is an excess of childhood cancer in North Wales. The Research Unit at Alder Hey Hospital in Liverpool, which treats the children from North Wales stated in an interview with HTV reporters that in 2002 there were 345 children hospitalised overnight whilst receiving treatment for cancer. In 2003 the figure was 437. If we take North Wales to

be the former counties of Gwynedd and Clwyd then we should expect about 14 cases per year in the 10,9842 population of 0-14 year olds at the 1991 census. Assuming the cancer treatment to last about three years, we should expect 42 children being treated at Alder Hey per year.

In this study, in keeping with the Busby 2000 findings, the children do seem to be located mainly in coastal areas e.g. Abersoch, Criccieth, Bermo, Treaddur. Of the 43 children identified, 33 of them (more than 75%) live within wards which have coastal contact. What is worrying also is the clear concentration of childhood cancer in the wards surrounding the Menai, its rapid increase in the most recent years and the high levels of leukaemia and brain and spinal tumours coupled with the existence of a case of retinoblastoma. Together, these findings support the earlier findings of a sea coast effect in Wales (Busby 2000) centred on the costal towns near the contaminated mud banks and raise serious questions about the establishment response to Green Audit's earlier reports and the safety of the statements on these effects by the Wales Cancer Intelligence and Surveillance Unit (WCISU), the Childhood Cancer Research Group (CCRG), COMARE and other players in this area e.g. the Leukaemia Research Fund, whose director of epidemiology, Ray Cartwright, was responsible for the recent hugely expensive (£16m) Childhood Cancer Research study.

It should be noted that the data used in this study represent baseline levels of illness. It is unlikely that the children who have been listed are the only children in the area with cancer or leukaemia; the real situation must be worse that that reported here.

The releases of radioactive material from Sellafield, particularly the alpha emitters Plutonium and Americium results in the build up of this material in fine sediment in areas of low tidal energy like this area of Wales and also north east Ireland. Plutonium from Sellafield has been measured in Welsh sediment and also in Welsh grassland at levels which show the existence of sea-to-land transfer in sea spray. The peculiar trend in cancer with distance from the sea, reported in Busby 2000, is well correlated with the measured trend in concentration of plutonium in air found by Eakins and Lally in Cumbria in 1984 and with the penetration inland by sodium chloride from seaspray.

It is our belief that these data show the same spectrum of illness in children that was found in Seascale and the Millom district coastal villages in Cumbria in 1983 and that the cause is the same. Excess childhood leukaemia has also been found near the Cap de la Hague reprocessing plant in France and a case control study identified playing near the sea as a correlating factor (Viel and Poubel, 1997). Childhood leukaemia has been reported to be high near estuaries in a 1990 study by Alexander et al. There have been reports also of excess childhood leukaemia in wards near Hinkley Point in Somerset, a nuclear power station which discharges to the sea and contaminates the muddy estuary of the River Parratt in Somerset.

Contamination of the Menai by radioisotopes from Sellafield is well documented (Assinder et al, 1994). The sea to land transfer of the radioactive material is also well understood and has been characterised (Eakins and Lally 1984, Eakins et al. 1984). That radioactive material is inhaled and becomes concentrated in the lymphatic system is known from autopsy measurements of plutonium (Popplewell, 1988) and measurements on children's teeth (Priest 1997). Calculations made by NRPB and used by COMARE (COMARE IV 1996) to address the Sellafield leukaemias concede the high levels of exposure of the lymphatic system but use the averaging techniques of the ICRP risk model to conclude that the dose is insufficient to be the cause of the leukaemias in the children (NRPB R-286, 1995). There are serious errors in the calculations used in these NRPB analyses which have been raised

by Green Audit with COMARE's Chair, Bryn Bridges but have not been addressed. Moreover, recent evidence from the increases in infant leukaemias in five countries following Chernobyl shows that the ICRP risk model is unsafe when applied to internal irradiation (Busby and Scott Cato 2000). The European Committee on Radiation Risk (ECRR2003) addresses these problems and their source in scientific philosophy and the committee's new rational model both predicts and explains the excess leukaemia at Sellafield. This model also would predict the effects found in North Wales in Busby 2000 and in the present study. Two questions remain. The first is why the WCISU, CCRG, COMARE and others have attempted to convince the authorities that there is no problem in north Wales. The second is how it is possible for the public to discover the existence of adverse health effects relating to environmental toxins if accurate cancer data is not made available for analysis, which is the present situation.

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