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For discussion

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Analysis of radiation associated cancers - Dalgety Bay, 2000-2009

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Analysis of radiation associated cancers

Dalgety Bay, 2000-2009

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Contents

Summary

This report describes an analysis of cancers associated with exposure to ionising radiation in the Dalgety Bay area of Fife, Scotland.
None of the cancers most frequently associated with radiation exposure were found to be significantly higher in incidence in the Dalgety Bay population compared to similar populations elsewhere in Scotland. There are significantly higher incidence rates of cancer of the liver and of Non-Hodgkin lymphoma, neither of which is considered to be strongly associated with ionising radiation.

Introduction

Radioactive particles have been found in the vicinity of Dalgety Bay since at least 1990 [1]. The source of this material is presumed to be military activity which took place in the area during and immediately after World War II. The Royal Naval Air Service improved and expanded an aerodrome, present since 1917, as HMS Merlin, an aircraft repair yard, and constructed an extensive aircraft maintenance facility [2]. It is believed that aircraft instruments made luminescent with radioactive materials, specifically radium paint, were discarded in the area during aircraft refitting or disassembly.

SEPA (2011)[3] report that discrete point sources retrieved from the area) with radioactive contamination could give rise to doses in excess of the 'minimum potential hazard' to humans, although the low level contamination of the environment at Dalgety Bay would not be high enough to warrant isolating the area as Radioactive Contaminated Land. Potential exposure pathways in the area are considered to be via inhalation, ingestion or (broken) skin contact.

There is evidence for associations between some cancers and exposure to radiation, and Boice (2006)(Appendix 1) describes the cancers in four groups, from 'frequently' to 'never or sporadically' associated with ionising radiation. Boice's groupings were used to structure the results of this report, which compares the incidence of radiation-associated cancers in the population of the Dalgety Bay area with that found in similar populations elsewhere in Scotland.

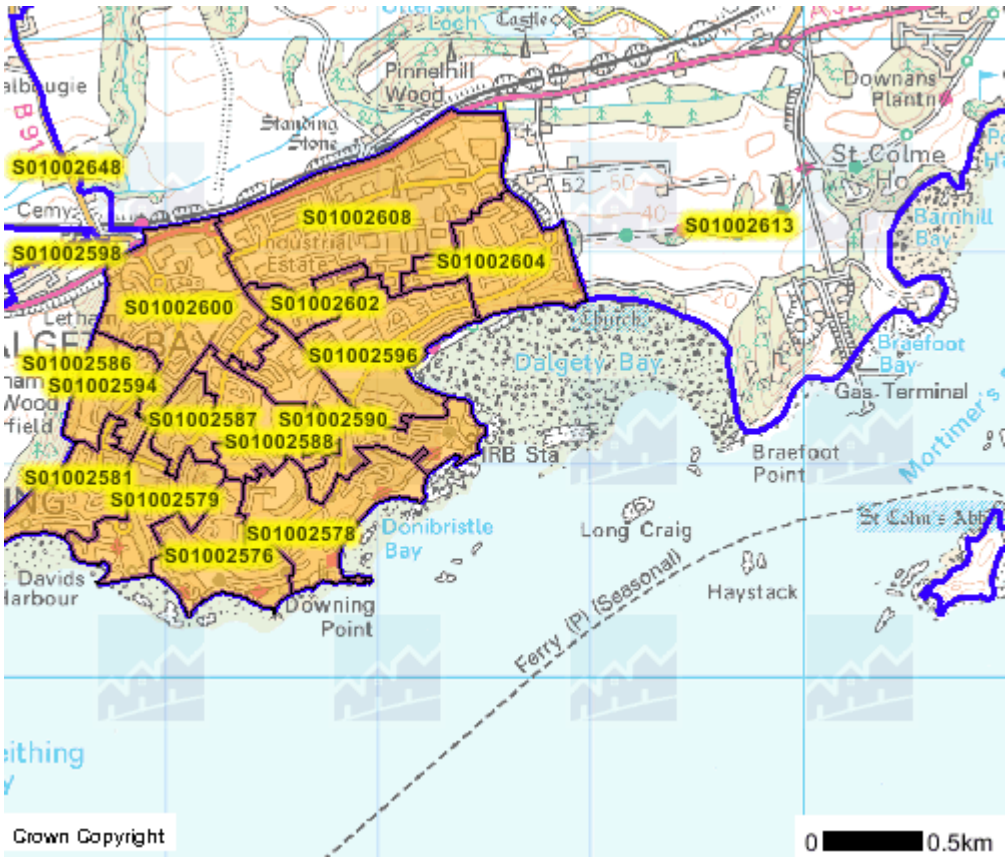
[1] http://www.sepa.org.uk/radioactive_substances/publications/dalgety_bay_reports.aspx

[2] http://www.fleetairarmarchive.net/aircraft/Airstations/FAAAirStationsHomepage.htm

[3] http://www.sepa.org.uk/radioactive_substances/publications/idoc.ashx?docid=716d7c47-bd36-41cf-aeb8-6b95a247e05d&version=-1

Methods

For the purpose of this analysis, Dalgety Bay has been defined as the 13 datazones between the Firth of Forth and A921 on the south and north, by Letham Hill to the west and the fields above Braefoot Point to the east. Datazones are a small-area geographies used by Scottish Neighbourhood Statistics, and are groups of 2001 Census output areas, with populations of between 500 and 1,000 household residents. Where possible, they have been made to respect physical boundaries and natural communities. They have a regular shape and, as far as possible, contain households with similar social characteristics [4].



The 13 datazones in the study are marked in orange. From Scottish Neighbourhood Statistics.

Dalgety Bay is a relatively affluent area; half of the postcodes contained in the datazones are in the least deprived 10% of the Scottish population, and all are in the least deprived 40%, using Scottish Index of Multiple Deprivation (SIMD) 2009 [5]. Lifestyles associated with this level of deprivation are reflected in the smoking prevalence rates, which at 17% are considerably lower than the Scotland average of 27% (Scottish Neighbourhood Statistics).

Most of the housing in Dalgety Bay is of recent build and the population has a relatively high turnover reflected in the high levels of house sales per capita as compared to Scotland as a whole (Scottish Neighbourhood Statistics).

Analyses of cancer incidence rates in Dalgety Bay were performed by comparing observed and expected numbers of cases in Dalgety Bay (compared to Scotland as a whole). The

[4] http://www.scotland.gov.uk/Publications/2005/02/20697/52626

[5] http://www.scotland.gov.uk/Topics/Statistics/SIMD

expected numbers of cases were calculated as the number of cancers that would be predicted in Dalgety Bay if the population experienced the same risk of cancer as other parts of Scotland with similar population characteristics. To accommodate the demographics of the 13 Dalgety Bay datazones under study, we used the two least-deprived deciles of the Scottish population to calculate the expected rates of cancer, which were then compared with Dalgety Bay.
A total of 20 types of cancer were grouped into the four levels of association with ionising radiation, as per Boice (2006)(Appendix 1). For each of the cancer types confidence intervals were calculated around the observed:expected ratio. Because of the large number of significance tests performed, the likelihood of observing statistical signficance due to random variation increases. To guard against this, confidence intervals were calculated at the 99% level.

Where the lower confidence interval is greater than 1.00 then the observed cases in Dalgety Bay are deemed to be statistically significantly higher than expected.; where the upper confidence limit is less than 1.00 Dalgety Bay has a significantly lower than expected incidence of that cancer.

Results

None of the cancer types frequently associated with ionising radiation were diagnosed in the Dalgety Bay population at a significantly higher rate than that seen in Scotland as a whole (Table 1).

Table 1. Cancers frequently associated with radiation with authoritative risk estimates (Boice, 2006 – see appendix 1)

	Observed cases (O)	Expected cases (E)	O/E	99% CI lower	99% CI upper	Scotland cases
Myeloid Leukaemia (C92)	6	4.9	1.23	0.42	2.91	3,025
Thyroid (C73)	3	2.9	1.03	0.23	3.19	1,609
Female breast (C50)	61	73.8	0.83	0.59	1.13	39,968
Total	70	81.5	0.86	0.63	1.15	44,602

CI – Confidence Interval

Of the group of cancers 'occasionally' associated with ionising radiation (Table 2), only liver was found to have significantly higher incidence.

Table 2. Cancers occasionally associated with radiation with robust risk estimates (Boice, 2006 – see appendix 1)

	Observed cases (O)	Expected cases (E)	O/E	99% CI lower	99% CI upper	Scotland cases
Lung (C34)	41	43.9	0.93	0.62	1.35	47,453
Stomach (C16)	6	10.0	0.60	0.20	1.42	8,331
Colon (C18)	34	38.9	0.87	0.56	1.31	24,083
Oesophagus (C15)	6	10.4	0.58	0.20	1.36	8,208
Bladder (C67)	9	10.4	0.86	0.36	1.78	7,651
Ovary (C56)	9	10.7	0.84	0.35	1.74	6,218
Brain and nervous system (C71-C72)	6	7.7	0.78	0.27	1.85	3,954
Liver (C22)	10	4.0	2.47	1.07 *	4.94	3,260
Total	121	136.0	0.89	0.70	1.11	109,158

CI – Confidence Interval
***** Statistically significantly higher than expected based on all-Scotland incidence rates

Of the groups of cancers that are rarely or never/sporadically associated with ionising radiation, only Non-Hodgkin lymphoma is more frequently diagnosed in the Dalgety Bay study area than expected based on incidence rates in the rest of Scotland (Tables 3 and 4).

Table 3. Cancers rarely associated with radiation with uncertain risk estimates (Boice, 2006 – see appendix 1)

	Observed cases (O)	Expected cases (E)	O/E	99% CI lower	99% CI upper	Scotland cases
Kidney (C64)	8	10.2	0.78	0.31	1.67	6,480
Salivary glands (C07-C08)	2	0.5	3.65	0.62	13.57	410
Non-Hodgkin lymphoma (C82-C85)	27	15.8	1.71	1.03 *	2.67	9,092
Myeloma (C90)	5	6.1	0.82	0.25	2.06	3,667
Skin (C43-C44)	20	22.7	0.88	0.84	1.22	9,265
Rectum (C19-C20)	18	19.9	0.90	0.48	1.55	12,012
Uterus (C54-C55)	12	9.7	1.23	0.57	2.34	5,744
Bone (C40-41)	0	0.4	0	0.12	6.26	215
Connective tissues (C47, C49)	2	2.9	0.69	0.04	2.16	1,474
Total	94	88.3	1.05	0.81	1.37	48,363

CI – Confidence Interval

* Statistically significantly higher than expected based on all-Scotland incidence rates

Table 4. Cancers never or sporadically associated with radiation with no risk estimates (Boice, 2006 – see appendix 1)

	Observed cases (O)	Expected cases (E)	O/E	99% CI lower	99% CI upper	Scotland cases
Chronic lymphocytic leukaemia (C91.1)	7	4.6	1.51	0.55	3.37	2,852
Pancreas (C25)	12	9.3	1.28	0.60	2.44	6,458
Hodgkin disease (C81)	7	2.6	2.68	0.99	6.00	1,438
Prostate (C61)	61	52.4	1.17	0.83	1.58	26,026
Testis (C62)	3	4.2	0.71	0.16	2.18	2,060
Cervix (C53)	3	3.6	0.83	0.19	2.56	2,978
Selected childhood cancers	0	0.4	0	0.01	4.61	167
Supporting tissues of skeleton	See footnote 1					
Total	95	78.2	1.22	0.93	1.56	42,427

CI – Confidence Interval

1. Supporting tissues: it is difficult to specify a list of diagnostic codes that would contain this group, most of which will be included in the Connective Tissues (C47,C49) category, so it is left intentionally blank.

Discussion

Latency between exposure to risk factors and the expression of cancer, and the mobility of the population mean that the results should be taken as indicative rather than definitive. It is only possible to infer indirectly exposure based on residence at the time of diagnosis of cancer. In reality, some exposed people may have moved elsewhere before their cancer was diagnosed, but conversely, some unexposed people may have developed cancer very shortly after moving into the area. Tissues are more sensitive to ionising radiation at younger ages, and the younger end of the population spectrum may be especially mobile.

Studies cited in Boice (2006) of cancers diagnosed in radium dial painters include bone cancers (osteosarcomas), but even in high-dose, long-term contact situations, studies show that no bone cancers would be expected to occurr below a 10 Gy threshold. In Dalgety Bay, exposure would be occasional and the highest exposure found was estimated at 128 mSV (to a 3 month old child), which would be roughly equivalent to 0.13 Gy whole-body exposure, much less than the observed threshold level for osteosarcoma.

In radium-dial painters, myeloid leukaemias were also presented, but the rate of diagnosis was correlated with the duration of occupational exposure rather than dose intake. In the radium-dial painters, there was no increase in liver cancer or breast cancer over that of the background population (Boice 2006, p271), so other possible risk factors, such as alcohol intake, must be considered.

While this analysis does not indicate any elevated level of cancers associated with ionising radiation, it does point out other cancer-related public health issues in the population of Dalgety Bay – higher than background levels of cancer of the liver and Non-Hodgkin lymphoma (NHL).

The age and sex distribution of liver cancer in the Dalgety Bay area does not differ from that found generally in Scotland. Three of the 10 cases are recorded as non-specific types of liver cancers ("malignant neoplasm, not otherwise specified"), which does raise the question as to whether these are genuine primary liver cancers (the liver is a common site for secondary spread from other primary cancers, and there is therefore scope for misclassification of the precise diagnosis).

The main recognised risk factor for primary liver cancer is cirrhosis, most often as a result of alcohol abuse or infection with viral Hepatitis B or C [6] .

The age and sex distribution of NHL in the Dalgety Bay area does not differ from that found generally in Scotland, and the numbers are too small to distinguish any difference in rates of specific types of NHL.
Generally, NHL is a portfolio of lymphoma diseases and has no single etiology; there is little consensus on the contributing risk factors to development of NHL, although it is agreed that there has been an increase in NHL worldwide [7]. Increased rates of NHL are found in workers within some industries, notably farming, forestry, paper and pulp production, rubber manufacture, woodworking and textiles, and associations of NHL with some pesticides and organicides have been found. Viral infections have also been associated with increased rates of NHL, either as a result of immunosuppression (eg post-transplant or HIV infection) or with other viral infections (eg Epstein-Barr) causing changes to cellular expression.

The risk of environmental exposure leading to a localised increase in cancer rates is difficult to determine from cancer registration statistics alone. Where statistical studies of the type we have conducted highlight a cause for concern, other types of epidemiological study may be carried out involving actual measurement of exposure levels and the exposure histories of those with and without a cancer diagnosis. A well-written fact sheet for the non-statistician, produced by the South West Public Health Observatory (click here), describes cancer clusters and the occurrence of cancer in the general population.

[6] http://cancerhelp.cancerresearchuk.org/type/liver-cancer/about/risks-and-causes-of-liver-cancer

[7] Hartge P, Wang SS, Bracci PM, Devesa SS, Holly EA. (2006) Non-Hodgkin Lymphoma. Chapter 46 in *Cancer Epidemiology and Prevention*, 3rd Edition. Oxford University Press.

Contact

Further Information

Appendix

A1 – List of radiation-associated cancers

CANCERS FREQUENTLY ASSOCIATED WITH RADIATION WITH AUTHORITATIVE RISK ESTIMATES
Leukaemia, especially Myeloid (C92)
Thyroid (C73) – little risk if exposed >20 yr age
Female breast (C50) – little risk if exposed >40 yr age

CANCERS OCCASIONALLY ASSOCIATED WITH RADIATION WITH ROBUST RISK ESTIMATES
Lung (C34) – interaction of smoking
Stomach (C16)
Colon (C18)
Oesophagus (C15)
Bladder (C67)
Ovary (C56)
Brain and nervous system (C71-C72) – mainly after high-dose childhood exposure
Liver (C22)

CANCERS RARELY ASSOCIATED WITH RADIATION WITH UNCERTAIN RISK ESTIMATES
Limited evidence:
Kidney (C64)
Salivary glands (C07-C08)
Non-Hodgkin lymphoma (C82-C85)
Myeloma (C90)
Effect may be limited to high doses:
Skin (C43-44)
Rectum (C19-C20)
Uterus (C54-C55)
Bone (C40-41)
Connective tissues (C47, C49)

CANCERS NEVER OR SPORADICALLY ASSOCIATED WITH RADIATION WITH NO RISK ESTIMATES
Chronic lymphocytic leukaemia (C91.1)
Pancreas (C25)
Hodgkin disease (C81)
Prostate (C61)
Testis (C62)
Cervix (C53)
Certain childhood cancers (ICD-O M8960, 9490, 9500, 9510-9513, age 0-14)

Source: Table 15-1, page 260, Boice Jr, JD (2006). Ionizing radiation. In Schottenfeld D and Fraumeni Jr, JF (eds). Cancer Epidemiology and Prevention. Third Edition, Oxford University Press.