CUMULATIVE RADIATION EXPOSURE AT BNFL SELLAFIELD: A HISTORICAL PERSPECTIVE

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ABSTRACT

The temporal distribution of the average cumulative whole body annual recorded external radiation doses of 15,182 monitored male Sellafield employees is presented. Results are given for successive pairs of years of first monitoring, from 1949-50 to 1985-86, and for successive single years of follow up for each of these cohorts. The results show: there is a reduction in average cumulative dose with later years of first monitoring at any length of follow up; a marginal reduction in the increase in the average cumulative dose for any given cohort with longer length of follow up; and the pattern of average dose in the first year of follow up is similar to that previously reported, in [1].

INTRODUCTION

Historical annual recorded whole body dose data for Sellafield employees were computerised as a special exercise by a dedicated team of British Nuclear Fuels plc (BNFL) Sellafield staff in the late 1970's. This computerised annual dose database has had the annual dose data for all Sellafield employees added to it up to 1986. These dose data together with personnel and tracing return data form part of the BNFL Company Epidemiology database and are held on computer in the Company Medical Office at the Sellafield site. Extracts from the Epidemiology database have been supplied to researchers for use in a range of studies, published and forthcoming eg. [1,2,3,4]. The Sellafield employee data have been combined with equivalent data for the Atomic Energy Authority (AEA) and the Atomic Weapons Establishment (AWE) by Harwell staff to form the Nuclear Industry Combined Epidemiological Analysis (NICEA) database. These data, which will be analysed by epidemiologists at the London School of Hygiene and Tropical Medicine (LSHTM), have been transferred to the International Agency for Research on Cancer (IARC) for combining with American and Canadian data, for analysis by IARC staff.

THE DISTRIBUTION OF ANNUAL EXTERNAL DOSE DATA

The Sellafield whole body annual dose data are, as with other such data [5], in their own right of considerable epidemiological interest. There are 15,182 male radiation workers on this database who have been occupationally exposed to 1307 Sv during 112,582 person years of employment. Only the first episode of continuous employment as a monitored worker and those annual external doses recorded during that employment period are used for the results of this paper.

AVERAGE CUMULATIVE ANNUAL EXTERNAL WHOLE BODY DOSES IN mSv (UPPER SUCCESSIVE PAIRS OF YEARS OF FIRST MONITORING, STARTING IN 1949-50, OF ALL AGES WHILE CONTINUOUSLY MONITORED DURING THEIR FIRST EMPLOYMENT

Year of first monitoring	Years of follow-up 1	2	3	4	5	6	7	8	9
49-50	2.3	7.3	30.8	59.5	83.8	109.7	143.9	178.8	200.7
51-52	6.9	26.7	45.7	62.9	82.8	106.4	127.2	141.1	158.2
53-54	10.1	24.8	42.9	64.0	81.2	96.1	114.4	134.5	150.3
55-56	8.9	28.4	44.9	60.6	78.3	96.1	112.1	125.1	137.9
57-58	8.8	24.4	43.8	61.7	78.9	94.6	108.8	125.2	144.1
59-60	8.8	23.0	35.9	47.6	56.8	68.2	84.6	102.4	118.9
61-62	5.6	14.8	22.4	32.3	46.5	63.6	82.5	100.1	115.7
63-64	3.4	10.1	18.1	26.7	39.1	49.2	61.0	73.5	83.0
65-66	5.1	15.0	26.5	40.1	53.8	70.1	85.7	100.9	116.7
67-68	7.0	20.5	35.0	52.2	71.9	86.5	103.8	119.2	131.6
69-70	5.0	16.6	31.5	46.1	58.2	73.2	87.0	97.2	109.1
71-72	7.6	22.1	37.1	52.5	69.8	83.8	95.9	109.0	121.9
73-74	7.6	23.3	41.3	56.8	71.0	84.4	97.9	112.2	124.8
75-76	8.1	22.3	36.9	51.0	65.7	81.4	94.3	105.5	116.1
77-78	5.3	15.0	25.4	35.4	44.4	52.9	61.5	69.5	73.4
79-80	4.9	12.6	20.6	28.9	37.0	44.2	48.7	59.7	
81-82	3.0	7.2	12.6	19.3	23.4	29.8			45
83-84	1.9	7.3	10.4	12.2			30	100	113
85-86	2.3	5.8			39	62	69	78	85
			36	88	110	143	165	177	197
49-50	0	20	24	32	38	43	45	48	58
Years of follow-up	38	37	36	35	34	33	32	31	30

Year of first monitoring	Years of follow-up 20	21	22	23	24	25	26	27	28
49-50	428.6	450.8	467.7	484.8	501.5	524.3	553.0	568.8	586.9
51-52	344.3	353.5	367.6	382.9	400.0	417.5	422.3	431.9	432.8
53-54	317.3	335.1	347.3	362.7	362.8	375.9	395.1	414.4	422.1
55-56	306.2	316.2	326.6	336.1	346.1	357.3	370.3	375.6	387.9
57-58	323.2	332.3	346.4	364.7	380.7	387.1	399.2	408.4	430.4
59-60	263.4	278.0	288.0	293.8	292.9	296.2	300.6	296.0	309.2
61-62	242.5	250.7	259.2	265.8	279.7	287.6	329.2		
63-64	194.2	198.6	212.4	215.2	199.8			255	548
65-66	228.4	234.3	276.5			86	222	231	238
67-68	225.3			93	166	172	174	179	183
		26	94	98	100	101	103	106	111
67-68	83	88	90	92	96	98	99	103	106
65-66	55	56	59	61	64	67	74	76	79
63-64	46	49	50	50	53	55	57	62	67
61-62	132	139	152	154	161	171	178	187	195
59-60	229	241	249	264	277	288	296	313	326
57-58	248	252	258	262	269	283	303	315	333
55-56	207	207	213	225	240	247	260	281	303
53-54	163	172	176	185	200	216	227	246	262
51-52	431	459	482	508	529	560	578	612	654
49-50	110	114	117	120	123	129	133	142	145
Years of follow-up	19	18	17	16	15	14	13	12	11

TRIANGULAR PART) AND NUMBERS OF EMPLOYEES (LOWER TRIANGULAR PART) BY BY YEARS OF FOLLOW-UP TO 1986 FOR MALE SELLAFIELD RADIATION WORKERS EPISODE

Year of first monitoring	Years of follow-up 10	11	12	13	14	15	16	17	18	19
49-50	219.6	245.4	266.3	288.1	300.2	319.3	334.5	358.8	379.0	403.9
51-52	177.7	194.9	211.1	223.7	236.9	256.4	275.8	294.0	311.6	330.4
53-54	163.8	173.9	187.4	201.5	218.4	236.0	251.1	270.7	285.2	304.0
55-56	152.9	170.2	188.5	208.2	229.4	244.6	257.3	271.0	282.8	295.7
57-58	161.3	180.7	201.0	219.0	239.2	257.8	275.4	290.7	302.1	313.5
59-60	137.3	150.0	165.0	177.8	191.6	206.0	221.2	235.5	247.1	254.3
61-62	132.7	146.5	160.4	172.6	184.7	196.3	206.9	215.0	228.6	237.8
63-64	93.9	94.9	105.3	124.3	139.3	148.3	163.5	171.3	180.5	189.6
65-66	132.4	142.2	156.1	165.9	176.0	184.4	191.1	203.1	217.3	227.4
67-68	143.3	154.9	165.5	178.3	186.2	192.0	199.1	204.5	213.2	208.1
69-70	119.6	136.3	146.9	156.2	164.4	171.1	175.6	179.2	149.1	
71-72	135.0	144.9	153.5	158.8	165.9	171.7	182.4			26
73-74	135.6	147.5	157.0	162.4	146.8			22	52	54
75-76	126.7	131.3	160.1			6	40	42	45	45
77-78	76.1			55	97	102	108	114	118	123
		69	143	154	166	176	184	188	201	221
57-58	127	144	154	163	171	183	191	206	225	236
55-56	127	136	146	149	153	165	172	178	187	194
53-54	92	98	102	110	122	126	142	148	156	159
51-52	217	232	249	271	297	321	350	364	383	409
49-50	60	66	72	75	79	81	89	94	99	106
Years of follow-up	29	28	27	26	25	24	23	22	21	20

Year of first monitoring	Years of follow-up 29	30	31	32	33	34	35	36	37	38
49-50	622.0	631.5	665.3	666.5	673.0	685.7	704.0	721.3	750.7	750.0
51-52	437.3	443.1	444.5	443.1	427.8	463.2	483.9	463.1		
53-54	425.8	440.5	446.9	462.1	466.9	472.3			495	1210
55-56	394.5	393.8	395.5	365.0			213	539	609	668
57-58	443.0	460.0			208	408	449	537	690	798
			389	815	868	900	944	1011	1090	1191
77-78	322	757	785	814	850	891	937	1032	1185	1387
75-76	562	581	599	607	643	720	817	935	1083	1248
73-74	246	254	265	282	311	340	371	399	466	549
71-72	186	197	207	220	234	247	277	318	368	438
69-70	126	135	154	158	174	195	214	232	282	343
67-68	108	110	119	139	151	157	176	213	242	294
65-66	83	88	96	105	112	125	143	180	223	299
63-64	73	76	81	89	98	105	134	173	208	259
61-62	210	223	238	256	303	379	443	537	660	842
59-60	337	361	403	465	534	618	717	851	1052	1189
57-58	365	414	467	505	559	627	737	804	893	995
55-56	329	353	380	404	441	478	514	586	700	768
53-54	280	290	301	314	337	375	416	496	635	731
51-52	687	719	756	799	876	1014	1164	1319	1478	1610
49-50	151	159	167	185	223	254	279	307	336	363
Years of follow-up	10	9	8	7	6	5	4	3	2	1

The distribution of average cumulative whole body annual recorded doses for these male Sellafield employees (all ages) is given in the table. The upper triangular part of the table gives the average cumulative dose by successive pairs of calendar years of first year of monitoring and for successive years of follow-up through to 1986. The lower triangular part of the table gives the respective numbers of workers.

Comparison of the average doses in the first year of follow up for these cohorts with those of figure 3 of [1], shows that the average dose patterns are similar when it is noted that a worker will not normally contribute a full year of dose during his first year of employment.

Examination of the pattern of average cumulative dose for each successive pairs of years of first monitoring suggests an initially constant annual rate of accumulation of dose, with this rate reducing in later years of follow up. This dose accumulation rate is higher in earlier cohorts. An examination of the data for those workers continuously employed through to 1985 (eg. 20 for the 1949-50 cohort, 94 for the 1969-70 cohort, etc) supports this notion of a genuine reduction in individual average annual dose with increasing length of follow up.

CONCLUSIONS

This preliminary analysis draws out some features of these data, but further work is needed to better understand these data, particularly with respect to age at exposure and occupation. These results are consistent with a reduction in annual external whole body doses received by Sellafield workers over the follow up period.

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