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An Update on Mortality among Workers at a 1,3-Butadiene Facility—Preliminary Results

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This is a cohort study of 2582 male workers employed at least 6 months between 1943 and 1979 at a 1,3-butadiene manufacturing facility. An earlier report on mortality through 1979 found a statistically significant deficit for all causes of death and lower than expected mortality for most of the leading causes of death. However, there was a statistically significant excess of deaths from lymphosarcoma. This report is a preliminary update of cohort information through 1985 and also a reanalysis of mortality. The all-causes standardized mortality ratio is 84 and that for all cancers is 80. These are statistically significant deficits; significant deficits were also seen for all cancer of the digestive system and all external causes of death. One additional death from lymphosarcoma was observed during the extended follow-up period giving a statistically significant standardized mortality ratio (SMR) of 229. The increase was concentrated in those employed less than 10 years and in those first employed before 1946. No increase was seen overall for leukemia (SMR = 102).

Introduction

This study reports on updated cause-specific mortality in a cohort of workers employed at a 1,3-butadiene production plant. The plant was built during World War II in Port Neches, TX, to supply 1,3-butadiene to two adjacent rubber manufacturing facilities. This cohort was the subject of an earlier report (*1*) that covered the period from the beginning of plant operation through 1979. The cohort consisted of all males who were employed at the plant for at least 6 months between the time the plant began operation in 1943 and the end of 1979.

The earlier report found a statistically significant deficit for all causes of death and lower than expected mortality for almost all the leading causes of death. The only significant excess cause of death seen was for lymphosarcoma and reticulum cell sarcoma. The cohort was divided into four exposure groups (routine, nonroutine, low, and unknown) and mortality was examined for each of the groups. The standardized mortality ratios (SMRs) for non-Hodgkin's lymphomas (International Classification of Diseases codes 200, 202, 203, and 208) were elevated in all three known exposure groups. Direct comparisons between the low exposure group and each of the exposure groups for this cause of death were inconsistent. Because of the continuing interest in determining whether 1,3-butadiene is a human carcinogen, information on the original cohort was updated through 1985.

Methods

The study population is the same as that in the earlier report (*1*). The data were obtained from the previous investigators and merged with company computerized personnel files. Company data were used to update information on those persons still employed or known to be deceased. Dates of termination were obtained for those who left after the previous study end date. Further edits were done, and two duplicate records and two females were removed from the cohort.

Information was obtained from the Social Security Administration (SSA) for those whose vital status was unknown. This included all persons not known to be currently working for the company or those noted as deceased but for whom a death certificate was not located. SSA data were complete through 1985 although a number of deaths in 1986 and 1987 were also identified. Death certificates were requested from the states identified by SSA as most likely to have the information. At the time of this report, death certificates had been received from Texas, Louisiana, Ohio, and Mississippi. All death certificates were coded for underlying cause of death by a trained nosologist according to the Eight Revision rules of the International Classification of Diseases (ICD). Information on those whose vital status was unknown after the SSA search was submitted to the

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National Death Index (NDI). The NDI records were searched for possible matches for deaths from 1979 through 1986.

The qualitative exposure classification scale developed for the previous report (*1*) was again used. There were four exposure groups: low exposure, routine exposure, nonroutine exposure, and unknown exposure. Each person was assigned to an exposure group based on his department code. Although no industrial hygiene sampling data are available for most of the period covered by the study, a review of current sampling data results supports the groupings.

Analysis of mortality was performed using Monson's computer program (*2*) to compare the observed and expected number of deaths with the U.S. white male population as the comparison group. White male rates were used because of uncertainties about the validity of the race information in the company files and because of the small number of blacks who worked at the plant. Person-years were accrued beginning when the person met the cohort eligibility criteria of 6 months of employment. Those persons with vital status unknown were assumed to be lost to study on the date last observed. Those persons who were alive as of the earlier study end-date of 12/31/79 and for whom the NDI could find no match were assumed to be alive. Persons known to be deceased but for whom no death certificate could be located were counted in the all-causes mortality but not in the cause-specific mortality results.

It should be noted that while the previous report (*1*) grouped all the non-Hodgkin's lymphomas together in the tables (ICD codes 200, 202, 203, and 208), for this report lymphosarcoma (ICD code 200) and cancers of other lymphatic tissue (ICD codes 202, 203, and 208) are reported separately.

Results

The final cohort consisted of 2582 men who had worked for at least 6 months prior to the end of 1979. Table 1 shows the demographic and other characteristics of the total cohort and of the four exposure cohorts described above. There were 74,219 person-years of follow-up, and the mean duration of survival was 28.7 years. There were 826 deaths known to have occurred in the cohort through 1985, and death certificates were obtained for all but 49 (6%) of them. There were 1708 persons still alive at the end of the study (66%) and 48 (1.9%) lost to follow-up.

Table 2 shows the SMRs for selected causes of death for the total cohort and for those employed greater than 5, 10, and 20 years. The SMR for all causes of death for the total cohort is significantly low at 84, as well as the all-cancer SMR at 80. Deficits are again seen for almost all the leading causes of death. There is an elevated SMR of 130 for lymphatic and hematopoietic cancer, which is almost entirely due to the significantly increased SMR of 229 for lymphosarcoma and reticulosarcoma. The increase for lymphosarcoma is seen primarily in those employed fewer than 10 years. The only cause of death that increases as years of employment increases is cancer of the kidney, but both the observed and expected

Table 1. Demographic, employment, and other characteristics of the study population and exposure cohorts.

Cohort	Low exposure I	Routine exposure II	Nonroutine exposure III	Unknown exposure IV	Total
Number of persons	433	705	993	451	2582
Percent of total	(16.9%)	(27.3%)	(38.5%)	(17.5%)	(100%)
Mean age of entry, years	30.7	27.5	32.5	32.0	30.7
Mean year of entry	1954	1952	1951	1949	1952
Number hired between 1940–45	165	216	462	223	1066
Percent of cohort	(38%)	(31%)	(47%)	(49%)	(41%)
Mean years of employment	12.4	12.4	11.6	14.3	12.4
Number of lost to follow-up	6	6	26	10	48
Percent of each cohort	(1.4%)	(0.9%)	(2.6%)	(2.2%)	(1.9%)
Number of person-years	11851.7	21423.1	27433.8	13512.8	74218.8
Number of deaths	131	163	361	171	826
Percent of deaths in each cohort	(30.0%)	(23.1%)	(36.4%)	(37.9%)	(32.0%)
Number without death certificates	11	9	24	5	49
Percent of deaths	(8.4%)	(5.5%)	(6.7%)	(2.9%)	(6.0%)
Mean age at death, years	64.1	59.2	64.2	65.3	63.4
Mean year of death	1973	1973	1970	1971	1971
Mean duration of survival, years	27.4	30.4	27.1	30.0	28.7

Table 2. Observed and expected deaths and SMRs for selected causes for cohort members by length of employment.

	Total cohort n = 2582, P-Y = 74219				Employed > 5 years n = 1362, P-Y = 33959				Employed > 10 years n = 1096, P-Y = 24167				Employed > 20 years n = 781, P-Y = 11634			
Cause of death (8th ICDA[a])	Observed deaths	Expected deaths	SMR[a]	95% CI[a]	Observed deaths	Expected deaths	SMR	95% CI	Observed deaths	Expected deaths	SMR	95% CI	Observed deaths	Expected deaths	SMR	95% CI
All causes	826	979.6	84	79–90	433	516.6	84	76–92	354	440.8	80	72–89	200	258.6	77	67–89
All cancers (140–209)	163	202.7	80	69–94	83	109.0	76	61–94	69	94.9	73	57–92	47	61.5	76	56–102
Cancer of buccal cavity and pharynx (140–149)	5	6.1	82	26–190	3	3.3	92	18–268	2	2.8	71	8–256	2	1.8	110	12–398
Cancer of digestive system (150–159)	39	56.3	69	49–95	16	30.2	53	30–86	15	26.1	58	32–95	11	16.0	69	34–123
Cancer of esophagus (150)	3	4.8	63	13–184	0	2.6	0	0–143	0	2.2	0	0–164	0	1.5	0	0–248
Cancer of stomach (151)	4	10.2	39	11–100	0	5.4	0	0–68	0	4.5	0	0–82	0	2.4	0	0–151
Cancer of large intestine (153)	18	18.7	96	57–152	11	10.1	109	54–195	10	8.9	113	54–208	7	5.6	124	50–256
Cancer of rectum (154)	3	6.1	49	10–144	2	3.2	62	7–223	2	2.8	73	8–262	1	1.6	63	1–353
Cancer of liver (155–156)	1	4.3	24	0–131	0	2.3	0	0–162	0	1.9	0	0–190	0	1.2	0	0–319
Cancer of pancreas (157)	9	10.9	83	38–157	3	5.9	51	10–149	3	5.2	58	12–170	3	3.3	91	18–266
Cancer of respiratory system (160–163)	57	69.8	82	62–106	30	37.9	79	53–113	24	33.5	72	46–106	17	23.5	72	42–116
Cancer of the larynx (161)	4	3.0	136	37–347	0	1.6	0	0–232	0	1.4	0	0–266	0	0.9	0	0–407
Cancer of the lung (162–163)	53	66.2	80	60–105	30	35.9	83	56–119	24	31.8	75	48–112	17	22.4	76	44–122
Cancer of bone (170)	1	0.9	114	1–635	0	0.4	0	0–837	0	0.4	0	0–1050	0	0.2	0	0–2006
Cancer of skin (172–173)	3	3.5	86	17–252	1	1.8	55	1–304	1	1.5	66	1–365	1	0.9	108	1–602
Cancer of prostate (185)	10	14.6	69	33–126	8	8.1	99	43–195	8	7.3	110	47–216	4	4.4	91	25–234
Cancer of bladder (188)	3	6.2	49	10–142	2	3.4	59	7–214	2	3.0	67	8–242	2	1.8	111	12–400
Cancer of kidney (189)	5	5.0	100	32–234	4	2.7	150	40–383	4	2.3	173	46–442	3	1.5	198	40–578
Cancer of brain and central nervous system (191–192)	4	5.7	70	19–179	3	2.9	102	20–298	2	2.4	83	9–299	1	1.5	66	1–367
Lymphatic and hematopoietic cancer (200–209)	25	19.2	130	84–192	11	10.1	109	54–195	6	8.6	70	26–152	3	5.2	58	12–169
Lymphosarcoma and reticulosarcoma (200)	9	3.9	229	104-435	5	2.0	245	79–572	2	1.7	116	13–420	2	1.0	205	23–741
Hodgkin's disease (201)	3	2.1	141	28–413	1	1.0	99	1–551	1	0.8	134	2–743	0	0.4	0	0–1028
Leukemia and aleukemia (204–207)	8	7.9	102	44–200	2	4.2	48	5–174	1	3.5	28	0–158	0	2.1	0	0–176
Other lymphatic tissue (202, 203, 208)	5	5.1	97	31–227	3	2.8	106	21–311	2	2.5	80	9–289	1	1.7	58	1–323
Benign neoplasms (210–239)	2	2.7	74	8–266	1	1.4	73	1–403	0	1.1	0	0–325	0	0.7	0	0–550
Diabetes mellitus (250)	9	13.9	65	30–123	4	7.4	54	15–139	3	6.3	47	10–138	2	3.8	53	6–192
Arteriosclerotic heart disease (410–413)	250	345.8	72	64–82	137	187.9	73	61–86	109	163.7	67	55–80	58	95.7	61	46–78
Vascular lesions of central nervous system (430–438)	63	65.2	97	74–124	31	35.4	88	60–124	27	30.7	88	58–128	10	15.9	63	30–116
Nonmalignant respiratory disease (460–519)	49	62.1	79	58–104	32	33.6	95	65–135	27	29.8	91	60–132	12	18.1	66	34–116
Pneumonia (480–486)	23	21.1	109	69–164	18	11.1	163	96–257	15	9.6	156	87–257	7	5.0	140	56–289
Emphysema (492)	7	13.6	51	21–106	3	7.7	39	8–114	3	7.0	43	9–125	2	4.3	47	5–170
Cirrhosis of liver (551)	10	22.9	44	21–80	4	12.0	33	9–86	4	10.0	40	11–103	2	6.3	32	4–115
All external causes (800–998)	64	84.1	76	59–97	31	38.6	80	55–114	20	28.2	71	43–110	12	13.8	87	45–152

[a]8th ICDA, 8th International Classification of Diseases; SMR, standardized mortality ratio; 95% CI, 95% confidence interval.

Table 3. Observed and expected deaths and SMRs for selected causes for all cohort members by time first employed.

Cause of death (8th ICDA[a])	Employed < 1946 (war) n = 1066, P-Y = 33553				Employed ≥ 1946 (postwar) n = 1516, P-Y = 40666			
	Observed deaths	Expected deaths	SMR[a]	95% CI[a]	Observed deaths	Expected deaths	SMR	95% CI
All causes	593	693.4	86	79–93	233	286.2	81	71–93
All cancers (140–209)	106	140.9	75	62–91	57	61.8	92	70–120
Cancer of buccal cavity and pharynx (140–149)	3	4.2	72	14–211	2	2.0	102	11–367
Cancer of digestive system (150–159)	24	41.0	59	37–87	15	15.3	98	55–162
Cancer of esophagus (150)	3	3.3	91	18–267	0	1.5	0	0–250
Cancer of stomach (151)	2	7.8	26	3–93	2	2.5	81	9–293
Cancer of large intestine (153)	11	13.5	81	40–145	7	5.1	137	55–282
Cancer of rectum (154)	2	4.6	44	5–158	1	1.5	66	1–369
Cancer of liver (155–156)	0	3.1	0	0–117	1	1.1	90	1–502
Cancer of pancreas (157)	5	7.7	65	21–152	4	3.2	126	34–323
Cancer of respiratory system (160–163)	39	46.7	84	59–114	18	23.1	78	46–123
Cancer of the larynx (161)	3	2.1	146	29–426	1	0.9	112	1–624
Cancer of the lung (162–163)	36	44.2	82	57–113	17	22.0	77	45–124
Cancer of bone (170)	1	0.6	168	2–935	0	0.3	0	0–1303
Cancer of skin (172–173)	0	2.0	0	0–181	3	1.5	205	41–600
Cancer of prostate (185)	9	12.0	75	34–142	1	2.5	39	1–220
Cancer of bladder (188)	2	4.9	41	5–148	1	1.3	77	1–430
Cancer of kidney (189)	3	3.3	90	18–263	2	1.7	121	14–438
Cancer of brain and central nervous system (191–192)	2	3.3	60	7–218	2	2.4	83	9–301
Lymphatic and hematopoietic cancer (200–209)	16	12.7	126	72–205	9	6.5	138	63–262
Lymphosarcoma and reticulosarcoma (200)	7	2.6	269	108–555	2	1.3	155	17–558
Hodgkin's disease (201)	1	1.2	85	1–470	2	0.9	213	24–767
Leukemia and aleukemia (204–207)	6	5.4	112	41–244	2	2.5	80	9–287
Other lymphatic tissue (202, 203, 208)	2	3.4	59	7–212	3	1.7	174	35–509
Benign neoplasms (210–239)	2	1.8	111	12–401	0	0.9	0	0–399
Diabetes mellitus (250)	6	10.0	60	22–131	3	3.9	77	15–222
Arteriosclerotic heart disease (410–413)	176	254.6	69	59–80	74	91.2	81	64–102
Vascular lesions of central nervous system (430–438)	58	52.5	110	84–143	5	12.7	39	13–92
Nonmalignant respiratory disease (460–519)	33	47.5	70	48–98	16	14.6	109	62–178
Pneumonia (480–486)	16	16.4	98	56–159	7	4.7	148	59–305
Emphysema (492)	5	10.7	47	15–109	2	2.9	69	8–250
Cirrhosis of liver (551)	5	13.1	38	12–89	5	9.8	51	16–119
All external causes (800–998)	39	41.8	93	66–128	25	42.3	59	38–87

[a]8th ICDA, 8th International Classification of Diseases; SMR, standardized mortality ratio; 95% CI, 95% confidence interval.

numbers of deaths are small and the confidence intervals wide. One cause of death that is significantly elevated in this update, as compared to the previous report, is ill-defined symptoms and senility. (SMR = 200).

Table 3 shows the SMRs for selected causes of death for those first employed during World War II versus those who were first employed after the war. The all-causes SMR is similar for the two groups. The SMR is increased for lymphohematopoietic cancer for both subcohorts. Almost all the excess for those first employed during the war is due to the significantly elevated SMR for lymphosarcoma (SMR = 269). For those first employed after the war, elevated SMRs are seen for lymphosarcoma, Hodgkin's disease, and cancer of other lymphatic tissue. None of these is statistically significant, and the numbers of observed deaths are small. Cancers of the large intestine and the pancreas are nonsignificantly elevated for those first employed postwar, whereas deficits were seen for those first employed during the war. There is a slight elevation for leukemia (SMR = 112) in those first employed during the war, but it is based on less than one death.

Table 4 shows the SMRs for selected causes of death for each of the exposure groups for all in the subgroup and for those employed 10 years or more in the group. All groups except the unknown exposure group show elevated SMRs for lymphohematopoietic cancer for those ever in the group. For the low exposure group, the excess is due to elevated SMRs for lymphosarcoma and Hodgkin's disease; both of these are based on two or fewer observed deaths. The overall excess disappears when the analysis is restricted to those employed 10 years or more. The routine exposure group has a statistically significant excess of lymphosarcoma (SMR = 561), which accounts for most of the lymphohematopoietic excess. All of the lymphosarcomas occurred in persons employed fewer than 10 years. Cancer of both the large intestine and kidney increased from the group ever employed to those employed 10 years or more.

Most of the excess in lymphohematopoietic cancer for the nonroutine group is due to a nonsignificant increase in leukemia (SMR = 185), which is limited to those employed less than 10 years. Only a slight increase is seen for this group for lymphosarcoma (SMR = 126). Cancer of the prostate has a nonsignificant increase for those employed more than 10 years (SMR = 146), while there is a deficit for the group overall. There is a nonsignificant elevation for stroke for the group overall, but this disappears when the group is restricted to those employed more than 10 years. Cancer of the brain shows an elevated SMR (283) for the unknown exposure group, which increases for those employed more than 10 years (SMR = 415). These SMRs are based on three or fewer observed deaths, however. Both nonmalignant respiratory disease and cirrhosis of the liver show nonsignificantly elevated SMRs for the group employed 10 years or more, as compared to those ever in the group, but neither increase is statistically significant. The increase in respiratory disease is primarily due to an increase in deaths from pneumonia (SMR = 232).

The number of observed and expected deaths by years worked and latency for all males for all deaths, all cancer deaths, all hemotopoietic deaths, lymphosarcoma, and leukemia are shown in Table 5. For all deaths the SMRs are essentially unchanged as either latency or duration increases. Similarly, no pattern with latency or duration is seen for all cancer deaths. For all hematopoietic deaths, the largest elevation is seen for those with latency and length of employment fewer than 10 years. The SMRs actually decrease with increasing employment. For lymphosarcoma, again the largest elevation is for those with the shortest employment and latency. The SMRs for leukemia increase with increasing latency but decrease with increasing length of employment.

Tables 6 through 9 show the same information for each of the four exposure groups. No overall pattern is seen for the low-exposure group other than that the SMRs for all cancers and for all hematopoietic cancer tend to decrease with increasing lengths of employment. For the routine exposure group, again no pattern is seen. The biggest excess is seen for lymphosarcoma; all deaths occurred in those employed fewer than 10 years; two were in those with fewer than 10 years latency, one in those with 20 to 29 latency, and two in those with 30 years or more of latency. The most interesting result for the nonroutine exposure group is for leukemia. Five of the six deaths occurred in those employed fewer than 10 years, and all had at least 10 years of latency although the deaths were spread out among the other latency categories. No pattern was seen for the unknown exposure group.

Discussion

The overall pattern of results for this update is essentially unchanged from the earlier report on this cohort (*1*). There was an overall reduction in expected mortality (SMR = 84) when compared with the U.S. white male population, which again was primarily due to a reduction in deaths because of arteriosclerotic heart disease (SMR = 72). The major finding is still the significantly elevated SMR for lymphosarcoma. The group with the highest risk for this cause of death appears to be those employed fewer than 10 years, first hired during World War II, and employed in a job with the potential for routine exposure. The fact that the risk does not increase with increasing length of employment (and presumably increasing cumulative exposure) must be incorporated into any theory that this excess is related to 1,3-butadiene exposure.

Although the leukemia SMR is not elevated for the cohort overall, it is nonsignificantly elevated for the nonroutine exposure group. Half of the leukemia deaths in this group occurred in persons who were first employed during the war and employed less than 5 years. Overall, six of the eight total leukemia deaths were first employed during the war. Again, the risk does not increase with length of employment. The increased risk

Table 4. Observed and expected deaths and standardized mortality ratios for selected causes for

Cause of death (8th ICDA[a])	Exposure group I: low exposure ever employed n = 433, P-Y = 11852				Exposure group I: low exposure employed > 10 years n = 190, P-Y = 3995				Exposure group II: routine exposure ever employed n = 705, P-Y = 21422			
	Observed deaths	Expected deaths	SMR[a]	95% CI[a]	Observed deaths	Expected deaths	SMR	95% CI	Observed deaths	Expected deaths	SMR	95% CI
All causes	131	163.1	80	67-95	58	83.3	70	53-90	163	213.1	76	65-89
All cancers (140-209)	24	33.9	71	41-105	7	17.6	40	16-82	42	46.3	91	65-123
Cancer of buccal cavity and pharynx (140-149)	0	1.0	0	0-361	0	0.5	0	0-717	1	1.4	70	1-389
Cancer of digestive system (150-159)	9	9.4	96	44-183	2	4.9	41	5-148	9	12.0	75	34-142
Cancer of esophagus (150)	2	0.8	253	28-915	0	0.4	0	0-899	0	1.1	0	0-335
Cancer of stomach (151)	0	1.7	0	0-221	0	0.8	0	0-439	1	2.0	50	1-279
Cancer of large intestine (153)	4	3.1	127	34-326	2	1.7	119	13-430	4	4.1	99	27-253
Cancer of rectum (154)	0	1.0	0	0-366	0	0.5	0	0-706	1	1.2	81	1-452
Cancer of liver (155-156)	1	0.7	143	2-796	0	0.4	0	0-1022	0	0.9	0	0-413
Cancer of pancreas (157)	2	1.8	110	12-397	0	1.0	0	0-382	2	2.4	82	9-297
Cancer of respiratory system (160-163)	7	11.7	60	24-123	3	6.1	49	10-143	14	17.0	83	45-138
Cancer of the larynx (161)	0	0.5	0	0-747	0	0.3	0	0-1454	2	0.7	296	33-1070
Cancer of lung (162-163)	6	11.1	63	25-129	3	5.8	52	10-151	12	16.1	74	38-130
Cancer of bone (170)	0	0.1	0	0-2569	0	0.1	0	0-5740	1	0.2	516	7-2870
Cancer of skin (172-173)	2	0.6	351	39-1268	0	0.3	0	0-1354	0	0.9	0	0-413
Cancer of prostate (185)	0	2.5	0	0-147	0	1.5	0	0-246	2	2.6	77	9-277
Cancer of bladder (188)	0	1.1	0	0-351	0	0.6	0	0-623	1	1.2	84	1-467
Cancer of kidney (189)	2	0.8	241	27-871	1	0.4	237	3-1321	2	1.2	169	19-610
Cancer of brain and central nervous system (191-192)	0	0.9	0	0-391	0	0.4	0	0-877	0	1.5	0	1-242
Lymphatic and hematopoietic cancer (200-209)	4	3.2	126	34-323	1	1.6	63	1-352	8	4.5	177	76-349
Lymphosarcoma and reticulosarcoma (200)	2	0.6	321	36-1159	1	0.3	322	4-1791	5	0.9	561	181-1310
Hodgkin's disease (201)	1	0.3	294	4-1635	0	0.1	0	0-2843	1	0.6	179	2-998
Leukemia and aleukemia (204-207)	1	1.3	76	1-424	0	0.7	0	0-556	1	1.8	56	1-311
Other lymphatic tissue (202, 203, 208)	0	0.9	0	0-422	0	0.5	0	0-790	1	1.2	80	1-448
Benign neoplasms (210-239)	0	0.5	0	0-820	0	0.2	0	0-1775	0	0.7	0	0-566
Diabetes mellitus (250)	0	2.3	0	0-159	0	1.2	0	0-305	1	3.0	34	0-188
Arteriosclerotic heart disease (410-413)	43	58.1	74	54-100	23	31.2	74	47-111	48	72.5	66	49-88
Vascular lesions of central nervous system (430-438)	14	10.9	128	70-215	9	6.2	145	66-276	6	11.4	52	19-114
Nonmalignant respiratory disease (460-519)	10	10.6	95	45-174	6	5.9	103	37-223	9	12.7	71	32-135
Pneumonia (480-486)	3	3.5	85	17-248	2	1.9	104	12-374	3	4.0	75	15-220
Emphysema (492)	2	2.4	85	10-306	2	1.4	146	16-526	2	2.7	74	8-267
Cirrhosis of liver (551)	0	3.7	0	0-98	0	1.7	0	0-215	2	6.1	33	4-119
All external causes (800-998)	12	13.6	88	46-154	2	4.9	41	5-149	14	22.9	61	33-102

[a]8th ICDA, 8th International Classification of Diseases; SMR, standardized mortality ratio; 95% CI, 95% confidence interval.

for the category symptoms, senility, and ill-defined conditions is not readily explainable. The increase is concentrated in persons who were employed fewer than 20 years, were first employed during the war, and were not in the low exposure group. Obviously this category would decrease with more specific cause of death information from the attending physician.

Two other studies have examined mortality in cohorts exposed to 1,3-butadiene although both cohorts consisted of persons engaged in the manufacture of styrene-butadiene rubber (SBR) and so had the opportunity for multiple exposures. The first study by Matanoski and Schwartz (*3*) covered males who had worked at eight SBR manufacturing facilities in the U.S. and Canada. The overall SMR (81) was very similar to that seen for the current study. The only significant excess seen was for arteriosclerotic heart disease among black males. Risks were examined by major work areas as well as by pay grade, and no significant differences in cancer mortality for specific sites were seen. In particular, no increase was seen for lymphosarcoma (SMR = 49) or leukemia (SMR = 91).

The second study by Meinhardt et al. (*4*) covered persons employed at the two SBR plants supplied by the facility in the current study. The Meinhardt study found an elevated SMR for leukemia that was concentrated in people hired during the war. Elevated SMRs for lymphosarcoma were also seen although they were not statistically significant and were not as high as those seen in this study. One major problem with comparisons between the Meinhardt study and the current study is the overlap between the study cohorts. There were 116 persons who were employed both at the 1,3-butadiene and the SBR manufacturing facilities, including at least one of the leukemia deaths and one of the lymphosarcoma deaths. The increases for each of these populations may be exaggerated because of this.

Another report among oil refinery workers also saw an increase in a number of causes of deaths for those persons first employed during World War II (*5*). The increase was seen for many of the specific cancer sites including leukemia as well as for external causes of death. This study and the Meinhardt study show the elevation for leukemia but not for external causes of death. There are two possibilities for the wartime differences if they are real. One is that this group of people is

all cohort members by exposure group and length of employment.

Exposure group II: routine exposure employed > 10 years n = 270, P-Y = 6450				Exposure group III: Nonroutine ever employed n = 993, P-Y = 27434				Exposure group III: Nonroutine employed > 10 years n = 419, P-Y = 8714				Exposure group IV: Unknown ever employed n = 451, P-Y = 13513				Exposure group IV: Unknown employed > 10 years n = 217, P-Y = 5008			
Observed deaths	Expected deaths	SMR	95% CI	Observed deaths	Expected deaths	SMR	95% CI	Observed deaths	Expected deaths	SMR	95% CI	Observed deaths	Expected deaths	SMR	95% CI	Observed deaths	Expected deaths	SMR	95% CI
61	85.1	72	55-92	361	408.6	88	79-98	154	189.6	81	69-95	171	194.9	88	75-102	81	82.9	98	78-121
15	19.5	77	43-127	59	83.1	71	54-92	30	39.9	75	51-107	38	39.4	97	68-133	17	17.9	95	55-153
0	0.6	0	0-604	2	2.5	80	9-290	1	1.2	87	1-483	2	1.2	167	19-603	1	0.6	182	2-1015
5	5.1	99	32-231	10	23.6	42	20-78	4	11.2	36	10-91	11	11.3	98	49-175	4	4.9	81	22-208
0	0.5	0	0-777	0	1.9	0	0-189	0	0.9	0	0-396	1	0.9	108	1-599	0	0.4	0	0-855
0	0.8	0	0-457	1	4.4	23	0-126	0	1.9	0	0-187	2	2.2	93	10-336	0	0.9	0	0-427
4	1.7	233	63-596	7	7.8	90	36-185	3	3.8	79	16-230	3	3.7	82	16-238	1	1.6	61	1-340
0	0.5	0	0-727	0	2.6	0	0-142	0	1.2	0	0-304	2	1.2	161	18-580	2	0.5	381	43-1376
0	0.4	0	0-997	0	1.8	0	0-204	0	0.8	0	0-438	0	0.9	0	0-427	0	0.4	0	0-1005
1	1.0	96	1-535	2	4.5	45	5-161	1	2.2	46	1-255	3	2.1	141	28-413	1	1.0	103	1-571
4	7.4	54	15-138	24	27.9	86	55-128	10	13.7	73	35-135	12	13.2	91	47-159	7	6.4	110	44-227
0	0.3	0	0-1266	1	1.2	83	1-462	0	0.6	0	0-644	1	0.6	174	2-965	0	0.3	0	0-1380
4	7.1	57	15-1415	23	26.4	87	55-131	10	12.9	77	37-142	11	12.5	88	44-158	7	6.0	116	46-239
0	0.1	0	0-5335	0	0.4	0	0-1010	0	0.2	0	0-2480	0	0.2	0	0-2079	0	0.1	0	0-5318
0	0.4	0	0-1036	1	1.4	73	1-408	1	0.6	166	2-923	0	0.7	0	0-553	0	0.3	0	0-1231
1	1.1	89	1-494	5	6.5	77	25-180	5	3.4	146	47-341	3	3.0	100	20-292	2	1.3	159	18-574
0	0.5	0	0-721	1	2.7	37	0-208	1	1.4	74	1-411	1	1.3	80	1-444	1	0.5	186	2-1034
2	0.5	398	45-1436	1	2.0	50	1-276	1	1.0	105	1-586	0	1.0	0	0-382	0	0.4	0	0-825
0	0.6	0	0-615	1	2.2	45	1-253	0	0.9	0	0-398	3	1.1	283	57-827	2	0.5	415	47-1497
1	1.8	56	1-310	11	7.8	141	70-253	4	3.6	112	30-287	2	3.7	55	6-197	0	1.6	0	0-225
0	0.4	0	0-1017	2	1.6	126	14-454	1	0.7	141	2-783	0	0.7	0	0-503	0	0.3	0	0-1086
0	0.2	0	0-2081	1	0.8	122	2-677	1	0.3	344	4-1915	0	0.4	0	0-907	0	0.2	0	0-2394
0	0.7	0	0-523	6	3.2	185	68-403	1	1.5	67	1-371	0	1.5	0	0-239	0	0.7	0	0-554
1	0.5	185	2-1031	2	2.1	97	11-350	1	1.0	97	1-539	2	1.0	209	23-753	0	0.5	0	0-794
0	0.2	0	0-1507	2	1.1	182	20-656	0	0.5	0	0-790	0	0.5	0	0-702	0	0.2	0	0-1702
0	1.2	0	0-306	4	5.8	69	19-176	2	2.8	73	8-263	4	2.8	144	39-369	1	1.2	84	1-468
22	30.5	72	45-109	101	145.9	69	56-84	41	71.3	58	41-78	58	69.3	84	64-108	23	30.8	75	47-1212
1	4.6	22	0-120	36	28.9	124	87-172	12	14.3	84	43-146	7	13.9	50	20-104	5	5.6	90	29-209
2	5.3	38	4-137	20	26.6	75	46-116	12	13.3	90	47-157	10	12.3	81	39-149	7	5.3	132	53-271
1	1.5	65	1-363	10	9.2	109	52-200	8	4.5	180	77-354	7	4.4	160	64-331	4	1.7	232	62-594
0	1.2	0	0-311	3	5.9	51	10-150	1	3.2	31	0-175	0	2.7	0	0-136	0	1.3	0	0-285
0	2.5	0	0-147	4	8.8	46	12-117	1	3.8	27	0-148	4	4.3	93	25-238	3	2.0	148	30-433
4	6.9	58	16-148	27	32.0	84	56-123	10	10.7	94	45-172	11	15.6	71	35-126	4	5.7	70	19-179

somehow different from those hired at other times, perhaps because they were not eligible for the draft because of health reasons. The other is that there were major differences in exposure during the war that led to the increases.

In examining work history records for an earlier study of Texaco workers (*6*), it became obvious that a number of experienced persons were lent to the 1,3-butadiene plant during the war. In fact, 122 persons overlapped between the two studies. It is very likely that similar overlaps exist with cohorts from other petroleum and chemical facilities in the area. Since most of the elevations of interest were concentrated primarily in persons with short-term employment, the question remains of where else these persons were employed and what other exposures could have lasted substantially longer than those at the butadiene facility.

As mentioned in the earlier report on this cohort (*1*), there are several weaknesses in this study. Because of unreliable race designations, conclusions based on race-specific rates could not be generated. For this reason, all comparisons were made using white male mortality rates. Second, no work histories or industrial hygiene data were available for the time period of the study. Almost half of the cohort worked fewer than 5 years and obviously spent considerable working time elsewhere with the possibility for numerous other exposures. As mentioned above, it is this portion of the cohort where the increased SMRs are concentrated. Finally, the cohort size is small, and the numbers become even smaller for the exposure group analyses.

However, the study does cover one of the largest cohorts involved solely in the manufacture of butadiene. The cohort has been followed for 43 years and includes all those with 6 months or more employment since the plant began production. The numbers with vital status unknown (1.9%) and without cause of death information (6%) are relatively small, and qualitative measures of exposures were available.

Further efforts are underway to increase the information available for this cohort. Information has been received from the NDI for those persons with vital status unknown or for whom no death certificate could be located based on SSA information. There are outstanding requests for death certificates from other state health departments, and additional death certificates

Table 5. Observed and expected deaths by years worked and latency for the total cohort.

Years worked		Latency, years 0–9	10–19	20–29	30+	Totals
All deaths						
< 10	Observed	84	98	123	167	472
	Expected	101.3	91.8	145.9	199.9	538.9
	SMR[a]	8.3	107	84	84	88
10–19	Observed	—	56	54	44	154
	Expected	—	89.0	52.6	40.6	182.2
	SMR	—	63	103	108	85
20+	Observed	—	—	76	124	200
	Expected	—	—	100	158	258.0
	SMR	—	—	76	79	78
Totals	Observed	84	154	253	335	826
	Expected	101.3	180.8	298.5	398.5	979.6
	SMR	83	85	85	84	84
Cancer deaths						
< 10	Observed	11	19	26	38	94
	Expected	13.8	16.2	30.2	47.6	107.8
	SMR	80	117	86	80	87
10–19	Observed	—	7	9	6	22
	Expected	—	16.2	9.8	7.4	33.4
	SMR	—	43	92	81	66
20+	Observed	—	—	20	27	47
	Expected	—	—	22.1	39.3	61.4
	SMR	—	—	91	69	77
Totals	Observed	11	26	55	71	163
	Expected	13.8	32.4	62.1	94.3	202.7
	SMR	80	80	89	75	80
All hematopoietic deaths						
< 10	Observed	4	3	4	8	19
	Expected	2.0	1.9	2.8	3.9	10.6
	SMR	200	158	143	205	179
10–19	Observed	—	0	3	0	3
	Expected	—	1.8	0.9	0.6	3.3
	SMR	—	0	333	0	91
20+	Observed	—	—	2	1	3
	Expected	—	—	2.0	3.2	5.2
	SMR	—	—	100	31	58
Totals	Observed	4	3	9	9	25
	Expected	2.0	3.7	5.7	7.7	19.2
	SMR	200	81	158	117	130
Lymphosarcoma deaths						
< 10	Observed	4	0	1	2	7
	Expected	0.3	0.5	0.7	0.6	2.1
	SMR	1333	0	143	3333	3333
10–19	Observed	—	0	0	0	0
	Expected	—	0.5	0.2	0.1	0.8
	SMR	—	0	0	0	0
20+	Observed	—	—	2	0	2
	Expected	—	—	0.5	0.5	1.0
	SMR	—	—	400	0	200
Totals	Observed	4	0	3	2	9
	Expected	0.3	1.0	1.4	1.2	3.9
	SMR	1333	0	214	167	229
Leukemia						
< 10	Observed	0	1	2	4	7
	Expected	0.9	0.8	1.1	1.6	4.4
	SMR	0	125	182	250	159
10–19	Observed	—	0	1	0	1
	Expected	—	0.7	0.4	0.3	1.4
	SMR	—	0	2.5	0	71
20+	Observed	—	—	0	0	0
	Expected	—	—	0.8	1.3	2.1
	SMR	—	—	0	0	0
Totals	Observed	0	1	3	4	8
	Expected	0.9	1.5	2.3	3.2	7.9
	SMR	0	67	130	125	102

[a]SMR, standardized mortality ratio.

Table 6. Observed and expected deaths by years worked and latency for the low-exposure group.

Years worked		Latency, years 0–9	10–19	20–29	30+	Totals
All deaths						
< 10	Observed	14	11	17	31	73
	Expected	15.9	12.1	22.8	29.1	79.9
	SMR[a]	88	91	75	107	91
10–19	Observed	—	5	7	12	24
	Expected	—	16.2	9.7	8.2	34.1
	SMR	—	31	72	146	70
20+	Observed	—	—	10	24	34
	Expected	—	—	19.6	29.6	49.2
	SMR	—	—	51	81	69
Totals	Observed	14	16	34	67	131
	Expected	15.9	28.3	52.1	66.9	163.1
	SMR	88	57	65	100	80
Cancer deaths						
< 10	Observed	2	2	3	18	17
	Expected	2.2	2.1	4.8	7.2	16.3
	SMR	91	95	63	139	104
10–19	Observed	—	0	1	2	3
	Expected	—	3.0	1.7	1.3	6.0
	SMR	—	0	59	154	50
20+	Observed	—	—	3	1	4
	Expected	—	—	4.4	7.2	11.6
	SMR	—	—	68	14	35
Totals	Observed	2	2	7	13	24
	Expected	2.2	5.1	10.9	15.7	33.9
	SMR	91	39	64	83	71
All hematopoietic deaths						
< 10	Observed	1	0	0	2	3
	Expected	0.3	0.3	0.4	0.6	1.6
	SMR	333	0	0	333	188
10–19	Observed	—	0	0	0	0
	Expected	—	0.3	0.2	0.1	0.6
	SMR	—	0	0	0	0
20+	Observed	—	—	1	0	1
	Expected	—	—	0.5	0.6	1.1
	SMR	—	—	200	0	91
Totals	Observed	1	0	1	2	4
	Expected	0.3	0.6	1.0	1.2	3.2
	SMR	333	0	104	161	126
Lymphosarcoma deaths						
< 10	Observed	1	0	0	0	1
	Expected	0.1	0.1	0.1	0.1	0.4
	SMR	192	0	0	0	250
10–19	Observed	—	0	0	0	0
	Expected	—	0.1	0.0	0.0	0.1
	SMR	—	0	0	0	0
20+	Observed	—	—	1	0	1
	Expected	—	—	0.1	0.1	0.2
	SMR	—	—	1000	0	500
Totals	Observed	1	0	1	0	2
	Expected	0.1	0.1	0.2	0.2	0.6
	SMR	192	0	452	0	321
Leukemia						
< 10	Observed	0	0	0	1	1
	Expected	0.1	0.1	0.2	0.2	0.6
	SMR	0	0	0	442	167
10–19	Observed	—	0	0	0	0
	Expected	—	0.1	0.1	0.1	0.3
	SMR	—	0	0	0	0
20+	Observed	—	—	0	0	0
	Expected	—	—	0.2	0.3	0.5
	SMR	—	—	0	0	0
Totals	Observed	0	0	0	1	1
	Expected	0.1	0.2	0.4	0.5	1.43
	SMR	0	0	0	188	76

[a]SMR, standardized mortality ratio.

Table 7. Observed and expected deaths by years worked and latency for the routine exposure group.

Years worked		Latency, years 0–9	10–19	20–29	30+	Totals
All deaths						
< 10	Observed	14	20	26	42	102
	Expected	18.1	18.9	35.0	56.0	128.0
	SMR[a]	77	106	74	75	80
10–19	Observed	—	6	2	3	11
	Expected	—	13.7	3.0	3.8	20.5
	SMR	—	44	67	79	54
20+	Observed	—	—	19	31	50
	Expected	—	—	23.4	41.1	64.5
	SMR	—	—	81	75	78
Totals	Observed	14	26	47	76	163
	Expected	18.1	32.6	61.4	100.9	213.1
	SMR	77	80	77	75	76
Cancer deaths						
< 10	Observed	2	6	8	11	27
	Expected	2.1	3.2	7.5	14.0	26.8
	SMR	95	188	107	79	101
10–19	Observed	—	1	1	0	2
	Expected	—	2.3	0.6	1.0	3.9
	SMR	—	44	167	0	51
20+	Observed	—	—	5	8	13
	Expected	—	—	5.1	10.5	15.6
	SMR	—	—	98	76	83
Totals	Observed	2	7	14	19	42
	Expected	2.1	5.5	13.2	25.5	46.3
	SMR	95	127	106	75	91
All hematopoietic deaths						
< 10	Observed	2	1	1	3	7
	Expected	0.4	0.5	0.7	1.1	2.7
	SMR	500	200	143	273	259
10–19	Observed	—	0	0	0	0
	Expected	—	0.3	0.1	0.1	0.5
	SMR	—	0	0	0	0
20+	Observed	—	—	0	1	1
	Expected	—	—	0.5	0.8	1.3
	SMR	—	—	0	125	77
Totals	Observed	2	1	1	4	8
	Expected	0.4	0.7	1.3	2.0	4.5
	SMR	500	143	77	200	178.7
Lymphosarcoma deaths						
< 10	Observed	2	0	1	2	5
	Expected	0.1	0.1	0.2	0.2	0.6
	SMR	2000	0	500	1000	833
10–19	Observed	—	0	0	0	0
	Expected	—	0.1	0.0	0.0	0.1
	SMR	—	0	0	0	0
20+	Observed	—	—	0	0	0
	Expected	—	—	0.1	0.1	0.2
	SMR	—	—	0	0	0
Totals	Observed	2	0	1	2	5
	Expected	0.1	0.2	0.3	0.3	0.9
	SMR	2000	0	333	667	561
Leukemia						
< 10	Observed	0	0	0	1	1
	Expected	0.2	0.2	0.3	0.5	1.2
	SMR	0	0	0	200	83
10–19	Observed	—	0	0	0	0
	Expected	—	0.1	0.0	0.0	0.1
	SMR	—	0	0	0	0
20+	Observed	—	—	0	0	0
	Expected	—	—	0.2	0.3	0.5
	SMR	—	—	0	0	0
Totals	Observed	0	0	0	1	1
	Expected	0.2	0.3	0.5	0.8	1.8
	SMR	0	0	0	125	56

[a]SMR, standardized mortality ratio.

Table 8. Observed and expected deaths by years worked for the nonroutine exposure group.

Years worked		Latency, years 0–9	10–19	20–29	30+	Totals
All deaths						
< 10	Observed	43	46	53	65	207
	Expected	45.4	39.2	57.6	76.9	219.1
	SMR[a]	95	119	94	85	95
10–19	Observed	—	34	33	22	89
	Expected	—	41.2	29.3	22.2	92.7
	SMR	—	83	113	99	96
20+	Observed	—	—	24	41	65
	Expected	—	—	37.8	58.9	96.7
	SMR	—	—	64	70	67
Totals	Observed	43	80	110	128	361
	Expected	45.4	80.4	124.7	158.0	408.6
	SMR	95	100	88	81	88
Cancer deaths						
< 10	Observed	6	6	8	9	29
	Expected	6.5	7.0	11.8	18.0	43.3
	SMR	92	86	68	50	67
10–19	Observed	—	4	7	4	15
	Expected	—	7.7	5.5	3.8	17.0
	SMR	—	52	127	105	88
20+	Observed	—	—	6	9	15
	Expected	—	—	8.4	14.3	22.7
	SMR	—	—	71	63	66
Totals	Observed	6	10	21	22	59
	Expected	6.5	14.7	25.7	36.1	83.1
	SMR	92	68	82	61	71
All hematopoietic deaths						
< 10	Observed	1	1	2	3	7
	Expected	0.8	0.8	1.1	1.5	4.2
	SMR	125	125	182	200	167
10–19	Observed	—	0	3	0	3
	Expected	—	0.8	0.5	0.3	1.6
	SMR	—	0	600	0	188
20+	Observed	—	—	1	0	1
	Expected	—	—	0.7	1.1	1.8
	SMR	—	—	143	0	56
Totals	Observed	1	1	6	3	11
	Expected	0.8	1.6	2.3	2.9	7.8
	SMR	125	63	261	104	141
Lymphosarcoma deaths						
< 10	Observed	1	0	0	0	1
	Expected	0.1	0.2	0.3	0.2	0.8
	SMR	1000	0	0	0	125
10–19	Observed	—	0	0	0	0
	Expected	—	0.2	0.2	0.0	0.3
	SMR	—	0	0	0	0
20+	Observed	—	—	1	0	1
	Expected	—	—	0.2	0.2	0.4
	SMR	—	—	500	0	250
Totals	Observed	1	0	1	0	2
	Expected	0.1	0.4	0.6	0.4	1.6
	SMR	1000	0	167	0	126
Leukemia						
< 10	Observed	0	1	2	2	5
	Expected	0.4	0.3	0.4	0.6	1.7
	SMR	0	333	500	333	294
10–19	Observed	—	0	1	0	1
	Expected	—	0.3	0.2	0.2	0.7
	SMR	—	0	500	0	143
20+	Observed	—	—	0	0	0
	Expected	—	—	0.3	0.5	0.8
	SMR	—	—	0	0	0
Totals	Observed	0	1	3	2	6
	Expected	0.4	0.6	0.9	1.3	3.2
	SMR	0	167	333	154	185

[a]SMR, standardized mortality ratio.

Table 9. Observed and expected deaths by years worked for the unknown exposure group.

Years worked		Latency, years 0–9	10–19	20–29	30+	Totals
All deaths						
< 10	Observed	13	21	27	29	90
	Expected	22.0	21.7	30.6	37.8	112.1
	SMR[a]	59	97	88	77	80
10–19	Observed	—	11	12	7	30
	Expected	—	18.1	10.7	6.4	35.2
	SMR	—	61	112	109	85
20+	Observed	—	—	23	28	51
	Expected	—	—	19.2	28.5	47.7
	SMR	—	—	120	98	110
Totals	Observed	13	32	62	64	171
	Expected	22.0	39.8	60.5	72.7	194.9
	SMR	59	80	103	88	88
Cancer deaths						
< 10	Observed	1	5	7	8	21
	Expected	3.2	3.9	5.8	8.4	21.3
	SMR	31	128	121	95	94
10–19	Observed	—	2	0	0	2
	Expected	—	3.2	1.9	1.2	6.3
	SMR	—	63	0	0	32
20+	Observed	—	—	6	9	15
	Expected	—	—	4.1	7.3	11.4
	SMR	—	—	146	123	132
Totals	Observed	1	7	13	17	38
	Expected	3.2	7.1	11.8	16.9	39.4
	SMR	31	99	110	101	97
All hematopoietic deaths						
< 10	Observed	0	1	1	0	2
	Expected	0.4	0.4	0.6	0.7	2.1
	SMR	0	250	167	0	95
10–19	Observed	—	0	0	0	0
	Expected	—	0.4	0.2	0.1	0.7
	SMR	—	0	0	0	0
20+	Observed	—	—	0	0	0
	Expected	—	—	0.4	0.6	1.0
	SMR	—	—	0	0	0
Totals	Observed	0	1	1	0	2
	Expected	0.4	0.8	1.2	1.4	3.7
	SMR	0	125	83	0	55
Lymphosarcoma deaths						
< 10	Observed	0	0	0	0	0
	Expected	0.1	0.1	0.1	0.1	0.4
	SMR	0	0	0	0	0
10–19	Observed	—	0	0	0	0
	Expected	—	0.1	0.0	0.0	0.1
	SMR	—	0	0	0	0
20+	Observed	—	—	0	0	0
	Expected	—	—	0.1	0.1	0.2
	SMR	—	—	0	0	0
Totals	Observed	0	0	0	0	0
	Expected	0.1	0.2	0.2	0.2	0.7
	SMR	0	0	0	0	0
Leukemia						
< 10	Observed	0	0	0	0	0
	Expected	0.2	0.2	0.2	0.3	0.9
	SMR	0	0	0	0	0
10–19	Observed	—	0	0	0	0
	Expected	—	0.2	0.1	0.1	0.4
	SMR	—	0	0	0	0
20+	Observed	—	—	0	0	0
	Expected	—	—	0.2	0.2	0.4
	SMR	—	—	0	0	0
Totals	Observed	0	0	0	0	0
	Expected	0.2	0.4	0.5	0.6	1.5
	SMR	0	0	0	0	0

[a]SMR, standardized mortality ratio.

have been requested based on the NDI search results. The analyses will be repeated when these data are available. In addition, the company intends to continue to update cause of death information on the cohort at periodic intervals.

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