

A Proportional Mortality Study of Workers

Exposed to Vinyl Chloride 1947-74

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SUMMARY

The mortality experience of 433 employees who worked at The Firestone Tire & Rubber Company Pottstown complex and died during the period 1947-74 has been examined. Eighty-five of the 433 deceased employees worked in the chemical plant or plastics plant and were exposed to vinyl chloride; the remaining 348 worked in the tire plant and were not exposed to vinyl chloride. Death certificates were obtained for all 433 employees and the cause of death was coded according to the 8th revision of *The International List of Diseases and Causes of Death (1967)* by Michael Baden, M.D. Twelve additional employees have been identified as having died in the period 1947-74 (2 exposed and 10 nonexposed) but cause-of-death information was not available for these employees at the time of this analysis. The 445 employees who died since 1947 includes all workers who died while employed by Firestone or after their retirement. In addition, Firestone identified all of the employees who worked at Pottstown since 1947, had at least three years exposure to vinyl chloride, and terminated for some reason other than death or retirement. Of the 728 employees in this category (out of a total of 758 employees known to have worked in either the chemical plant or plastics plant), Firestone was able to trace all but 18 (2%) and verify that they are

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still alive (207 or 91%) or deceased (3 or 1%). No follow-up was performed on nonexposed ex-employees.

There was an excess of malignant neoplasms in both the exposed and nonexposed employees, and a statistically significant excess in major cardiovascular deaths in the nonexposed employees, compared with the U.S. male population (1968) adjusted for age at death (Table 1). Comparison of the exposed employees with the nonexposed employees shows a slight excess in malignant neoplasms and a small deficit in major cardiovascular deaths in the exposed (Table 2)--neither statistically significant. Further comparisons involving 4 subgroups of the exposed employees (< 10 years work exposure; $\geq$ 10 years work exposure; "low" level exposure; "medium" level exposure) show no significant differences between observed and expected deaths (Tables 3-8).

Two findings should be stressed:

- (1) One death due to angiosarcoma of the liver was confirmed in an employee, classified as having had "medium" level exposure, who died in 1969 at the age of 51--21 years after first exposure to vinyl chloride (with 19.4 years of work exposure). This single angiosarcoma death was the same one previously identified (independently) by Firestone.
- (2) The ages-at-death were significantly lower in the exposed employees compared with the nonexposed employees ($P < .05$); the mean ($\pm$ S.D.) ages of death being 55.3 ($\pm$ 13.1) - exposed and 59.5 ($\pm$ 14.6)-nonexposed (Tables 9 and 10). In particular, 21 out of the 22 deaths due to malignant neoplasms (95.5%) for the exposed employees occurred at ages < 65 compared with 44 out of 73 (60.3%) for the nonexposed. This difference is statistically significant at the 0.01 probability level. On the other hand, 32 out of the 46 deaths due to major cardiovascular diseases (69.6%) for the exposed employees occurred at ages < 65 compared with 121 out of 218 (55.5%) for the nonexposed--a

difference that is not statistically significant. Thus, the earlier ages noted for the cancer deaths in the exposed group of employees may not be solely attributable to a presumably younger cohort at risk.

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TABLE 1.-Observed and expected[†] number of deaths due to selected causes among exposed and nonexposed employees, 1947-74

Cause of death	List No. [†]	Observed (and expected) deaths	
		Exposed	Nonexposed
Malignant neoplasms	140-209	22(15.4)	73(61.1)
Digestive	150-159	8(4.3)	24(17.5)
Liver	155	1	3
Respiratory system	160-163	8(5.4)	25(19.9)
Urinary organs	188-189	1(0.8)	3(3.5)
Brain	191	1	3
Lymphatic and hematopoietic	200-209	1(2.1)	7(7.8)
Other	—	3	11
Major cardiovascular	390-448	46(41.1)	218(178.5)**
• Cirrhosis of liver	571	3(1.8)	4(5.7)
• Accidents	800-949	8(8.0)	21(28.9)
• Suicides	950-959	0(2.5)	6(8.3)
All other causes	—	6(16.2)	26(65.5)
Total	0-989	85(85.0)	348(348.0)

[†]Age-adjusted expected numbers determined from relative frequency of specific causes of death among U.S. white males in 1968.

[†]Eighth revision of *International List of Diseases and Causes of Death*, 1967.

**Statistically significant difference ($P < 0.01$).

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TABLE 2.-Observed and expected[†] number of deaths due to selected causes, with chi-square values, among exposed employees, 1947-74

Cause of death	List No. [†]	Number of deaths		Mantel-Haenszel summary Chi-square values
		Observed	Expected	
Malignant neoplasms	140-209	22	19.4	0.36
Digestive	150-159	8	6.5	0.23
Liver	155	1	1.0	0.33
Respiratory system	160-163	8	6.8	0.11
Urinary organs	188-189	1	0.7	0.09
Brain	191	1	1.0	0.33
Lymphatic and hematopoietic	200-209	1	1.9	0.00
Other	—	3	2.5	—
Major cardiovascular	390-448	46	50.5	1.08
Cirrhosis of liver	571	3	1.6	0.65
Accidents	800-949	8	6.7	0.18
Suicides	950-959	0	1.1	0.46
All other causes	—	6	5.7	—
Total	0-989	85	85.0	—

[†]Age-adjusted expected numbers determined from relative frequency of specific causes of death among the 348 nonexposed employees, with adaptation of the Mantel-Haenszel procedure.

[†]See footnote, table 1.

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TABLE 3.-Observed and expected[†] number of deaths due to selected causes, with chi-square values, among employees with < 10 years work exposure, 1947-74

Cause of death	List No. [†]	Number of deaths		Mantel-Haenszel summary Chi-square values
		Observed	Expected	
Malignant neoplasms	140-209	16	12.2	1.37
Digestive	150-159	6	4.0	0.71
Liver	155	0	0.6	0.01
Respiratory system	160-163	7	4.5	1.17
Urinary organs	188-189	0	0.8	0.23
Brain	191	0	0.6	0.01
Lymphatic and hematopoietic	200-209	1	1.4	0.02
Other	—	2	0.6	—
Major cardiovascular	390-448	26	31.0	2.10
Cirrhosis of liver	571	1	0.9	0.25
Accidents	800-949	7	4.9	0.87
Suicides	950-959	0	0.8	0.13
All other causes	—	3	3.2	—
Total	0-989	53	53.0	—

[†]See footnote, table 2.

[†]See footnote, table 1.

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TABLE 4.-Observed and expected[†] number of deaths due to selected causes, with chi-square values, among employees with ≥ 10 years work exposure, 1947-74

Cause of death	List No. [†]	Number of deaths		Mantel-Haenszel summary Chi-square values
		Observed	Expected	
Malignant neoplasms	140-209	6	6.8	0.01
Digestive	150-159	2	2.2	0.04
Liver	155	1	0.4	0.05
Respiratory system	160-163	1	2.2	0.26
Urinary organs	188-189	1	0.3	0.08
Brain	191	1	0.4	0.05
Lymphatic and hematopoietic	200-209	0	0.7	0.05
Other	—	1	1.0	—
Major cardiovascular	390-448	20	20.2	0.01
Cirrhosis of liver	571	2	0.5	1.88
Accidents	800-949	1	1.7	0.04
Suicides	950-959	0	0.5	0.00
All other causes	—	3	2.3	—
Total	0-989	32	32.0	—

[†]See footnote, table 2.

[†]See footnote, table 1.

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TABLE 5.-Observed and expected[†] number of deaths due to selected causes, with chi-square values, among employees with < 10 years work exposure, 1947-74

Cause of death	List No. [†]	Number of deaths		Mantel-Haenszel summary Chi-square values
		Observed	Expected	
Malignant neoplasms	140-209	16	14.8	0.15
Digestive	150-159	6	5.5	0.00
Liver	155	0	0.7	0.15
Respiratory system	160-163	7	5.2	1.12
Urinary organs	188-189	0	0.7	0.15
Brain	191	0	0.7	0.06
Lymphatic and hematopoietic	200-209	1	0.7	0.28
Other	—	2	2.0	—
Major cardiovascular	390-448	26	26.9	0.04
Cirrhosis of liver	571	1	1.7	0.07
Accidents	800-949	7	5.7	0.48
Suicides	950-959	0	0.0	0.00
All other causes	—	3	3.9	—
Total	0-989	53	53.0	—

[†]Age-adjusted numbers determined from relative frequency of specific causes of death among the 32 employees with ≥ 10 years work exposures, with adaptation of the Mantel-Haenszel procedure.

[†]See footnote, table 1.

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TABLE 6.-Observed and expected[†] number of deaths due to selected causes, with chi-square values, among employees in the "low" level exposed group, 1947-74

Cause of death	List No. [†]	Number of deaths		Mantel-Haenszel summary Chi-square values
		Observed	Expected	
Malignant neoplasms	140-209	11	10.2	0.01
Digestive	150-159	3	3.4	0.42
Liver	155	1	0.5	0.00
Respiratory system	160-163	4	3.6	0.00
Urinary organs	188-189	1	0.3	0.28
Brain	191	1	0.5	0.00
Lymphatic and hematopoietic	200-209	0	1.2	0.11
Other	—	2	1.2	—
Major cardiovascular	390-448	26	27.6	0.13
Cirrhosis of liver	571	2	1.0	0.35
Accidents	800-949	7	4.6	1.15
Suicides	950-959	0	0.8	0.12
All other causes	—	1	2.8	—
Total	0-989	47	47.0	—

[†] See footnote, table 2.

[†] See footnote, table 1.

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TABLE 7.-Observed and expected[†] number of deaths due to selected causes, with chi-square values, among employees in the "medium" level exposed group, 1947-74

Cause of death	List No. [†]	Number of deaths		Mantel-Haenszel summary Chi-square values
		Observed	Expected	
Malignant neoplasms	140-209	11	8.6	0.62
Digestive	150-159	3	2.8	0.03
Liver	155	1	0.5	0.00
Respiratory system	160-163	4	2.9	0.14
Urinary organs	188-189	1	0.4	0.03
Brain	191	1	0.5	0.00
Lymphatic and hematopoietic	200-209	0	0.9	0.19
Other	—	2	1.3	—
Major cardiovascular	390-448	20	23.9	1.52
Cirrhosis of liver	571	1	0.5	0.00
Accidents	800-949	1	1.9	0.11
Suicides	950-959	0	0.5	0.00
All other causes	—	5	2.6	—
Total	0-989	38	38.0	—

[†]See footnote, table 2.

[†]See footnote, table 1.

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TABLE 8.-Observed and expected[†] number of deaths due to selected causes, with chi-square values, among employees in the "low" level exposed group, 1947-74

Cause of death	List No. [†]	Number of deaths		Mantel-Haenszel summary Chi-square values
		Observed	Expected	
Malignant neoplasms	140-209	11	12.5	0.25
Digestive	150-159	5	4.6	0.00
Liver	155	0	0.5	0.00
Respiratory system	160-163	4	4.4	0.00
Urinary organs	188-189	0	0.6	0.01
Brain	191	0	0.5	0.00
Lymphatic and hematopoietic	200-209	1	0.7	0.28
Other	—	1	1.7	—
Major cardiovascular	390-448	26	24.0	0.48
Cirrhosis of liver	571	2	1.5	0.00
Accidents	800-949	7	5.3	1.01
Suicides	950-959	0	0.0	0.00
All other causes	—	1	3.7	—
Total	0-989	47	47.0	—

[†]Age-adjusted numbers determined from relative frequency of specific causes of death among the 38 employees in the "medium" level exposed group, with adaptation of the Mantel-Haenszel procedure.

[†]See footnote, table 1.

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Table 9.-Distribution of deaths by age and cause for exposed and nonexposed employees, 1947-74

Cause of Death	List No. [†]	Group [†]	Age at Death					Total
			≤ 34	35-44	45-54	55-64	≥ 65	
Malignant neoplasms	140-209	E	0	3	5	13	1	22
		NE	0	11	15	18	29	73
Digestive	150-159	E	0	1	3	4	0	8
		NE	0	2	6	5	11	24
Respiratory system	160-163	E	0	1	0	6	1	8
		NE	0	5	3	8	9	25
Urinary organs	188-189	E	0	0	1	0	0	1
		NE	0	0	0	1	2	3
Lymphatic and hematopoietic	200-209	E	0	1	0	0	0	1
		NE	0	0	4	2	1	7
Major cardiovascular	390-448	E	0	4	19	9	14	46
		NE	3	13	47	58	97	218
Cirrhosis of liver	571	E	0	0	1	1	1	3
		NE	0	1	2	1	0	4
Accidents	800-949	E	4	1	3	0	0	8
		NE	11	4	5	0	1	21
Suicides	950-959	E	0	0	0	0	0	0
		NE	1	2	1	0	2	6
All other causes	---	E	0	3	1	1	1	6
		NE	3	3	4	2	14	26
Total	0-989	E	4	11	29	24	17	85
		NE	18	34	74	79	143	348

[†]E = Exposed.
[†]NE = Nonexposed.

[†]See footnote, table 1.

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TABLE 10.-Distribution of age at death by year of death for exposed and nonexposed groups

Year of Death	Group [†]	Age at Death					Total
		≤ 34	35-44	45-54	55-64	≥ 65	
1947-54	E	1	0	0	0	0	1
	NE	8	3	11	8	3	33
1955-59	E	1	3	3	1	0	8
	NE	4	7	9	8	17	45
1960-64	E	0	2	10	6	1	19
	NE	2	11	14	16	31	74
1965-69	E	1	3	9	6	3	22
	NE	2	10	23	18	39	92
1970-74	E	1	3	7	11	13	35
	NE	2	3	17	29	53	104
Total	E	4	11	29	24	17	85
	NE	18	34	74	79	143	348

† E = Exposed
NE = Nonexposed

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