

IX. SUMMARY & CONCLUSIONS

This is the final report of a study of the mortality of workers exposed to vinyl chloride and its polymers, which augments studies reported in 1974 and 1975. The current report increases the total population of workers studied from 8,384 to 10,173, with the number whose vital status was determined increasing from 7,128 (85 percent) to 9,677 (95.1 percent). The number of deaths has more than doubled; there are now 669 certified and available for analysis, compared with 328 in the original study. The follow-up period concluded December 31, 1972, for both the original study and the augmented final study.

The successive additions to the population and improved follow-up have been accompanied by a rise in the overall-cause Standardized Mortality Ratio (SMR) from 75 in 1974 to 89 in the current analysis. The major change has been in the SMR for cardiovascular and renal disease, which was originally 80 and is now 95. There has been a concurrent downward shift in the SMR for "all malignancies," which is now 104 compared with 110 in the previous report.

In the current study the SMR's for malignancies of various sites are also lower than in the 1974 and 1975 reports. The SMR for gastrointestinal tract tumors dropped from 94 to 75 in successive reports (these included 5 deaths from hepatic angiosarcoma); that for respiratory tract cancer (uncorrected for smoking) dropped from 112 to 107; and that for cancer of other and unspecified sites from 155 to 147. There is, nevertheless, still some support for the hypothesis that vinyl chloride may increase the incidence of cancer slightly in sites other than the liver. The principal evidence for this is the observation that the incidence of lung cancer and miscellaneous cancers appears to be higher in individuals with higher maximum exposures

and those with longer exposure periods.

Brain tumors were found to be in excess, 12 observed vs. 5.9 expected (significant at the 0.05 level) but the incidence was not related to either duration of exposure or to intensity of exposure to VCM.

This population should be studied again within the next 5 years. Since the time of observation after first exposures will be longer, and more deaths will be available for analysis, it is possible that some of the questions about cancer in sites other than the liver may be resolved.

Table 1

Distribution of Vinyl Chloride Plants Studied
by Product and Numbers of Workers

<u>Product or Products</u>	<u>Number of Plants</u>	<u>Number of Workers</u>	<u>Number Traced</u>
Polyvinyl chloride only	18	6,848	6,468
Vinyl chloride monomer only	11	1,214	1,177
PVC and VCM	3	935	910
Copolymers, resins, with or without PVC and VCM	5	1,176	1,122
TOTALS	37	10,173	9,677

Table 2

Distribution of Vinyl Chloride Plants and Vinyl Chloride Workers
by Census Regions and Geographic Divisions

Region	Geographic Division	Percent of U.S. male Population (1970)	Number of Plants in Study	Number of Workers in Study	Number Traced
All regions		100.0	37	10,173	9,677
Northeast		23.8	8	1,619	1,550
	New England	5.8	2	467	453
	Middle Atlantic	18.0	6	1,152	1,097
North Central		27.9	6	1,872	1,817
	East North Central	19.8	6	1,872	1,817
	West North Central	8.0	-	--	--
South		30.9	22	6,589	6,218
	South Atlantic	15.1	5	1,735	1,620
	East South Central	6.3	4	2,868	2,655
	West South Central	9.5	13	1,986	1,943
West		17.4	1	93	92
	Mountain	4.1	-	--	--
	Pacific	13.2	1	93	92

Table 3

Follow-up

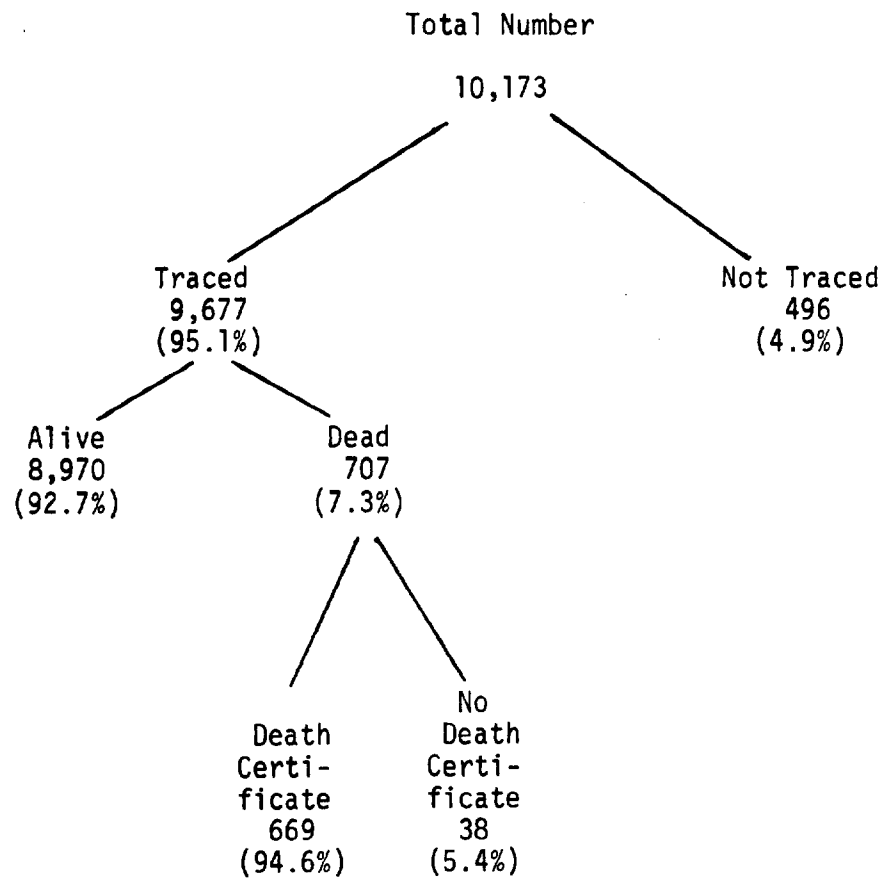


Table 4

Distribution of 9,677 Vinyl Chloride Workers by Duration of Exposed Employment and Interval from Beginning of Exposure to End of Study (December 31, 1972)

Interval From Beginning of Exposure to End of Study (Years)	Duration of Exposure (Years)						
	Total	1-4	5-9	10-14	15-19	20-24	25+
Total	9,677	4,384	2,339	946	1,007	677	324
0-9	4,193	2,720	1,473	0	0	0	0
10-14	931	305	228	398	0	0	0
15-19	1,323	352	164	208	599	0	0
20-24	1,525	489	192	149	196	499	0
25+	1,705	518	282	191	212	178	324

Table 5

Observed/Expected Deaths and Standardized Mortality
 Ratios for Selected Causes of Death in 9,677 Vinyl Chloride Workers

Cause of Death with ICD Number ^(a)	Obs./Exp.	SMR ^(b)
All causes	707/795.02	89**
All malignancies (140-205)	139/141.39	104
Malignant neoplasms, buccal and pharynx (140-148)	5/ 5.19	102
Malignant neoplasms, digestive organs and peritoneum (150-159)	29/ 40.82	75
Malignant neoplasms, respiratory system (160-164)	45/ 44.29	107
Malignant neoplasms, genital organs (170-179)	4/ 7.17	59
Malignant neoplasms, urinary organs (180-181)	8/ 6.85	123
Malignant neoplasms, other and unspecified sites (190-199)	28/ 20.18	147
Malignant neoplasms, brain and other parts of nervous system (193)	12/ 5.90	203*
Leukemia and aleukemia (204)	9/ 6.65	143
Lymphomas (200-203, 205)	11/ 10.36	112
Major cardiovascular and renal diseases (330-334, 400-468, 592-594)	347/385.24	95
Cirrhosis of liver (581)	14/ 26.45	56**
All other certified causes	169/241.95	74**
Number of workers	9,677	
Number of person-years	120,203	

a. Cause-specific numbers indicated categories in the 1955 (7th) revision of the International Classification of Diseases.

b. SMR's (other than for All Causes) adjusted for 38 deaths with no death certificates by factor of +5.68%

* Significant at the 0.05 level.

** Significant at the 0.01 level.

Table 6

Observed/Expected Deaths and Standardized Mortality Ratios for Selected Causes of Death
in Vinyl Chloride Workers, Grouped by Maximum Levels of Estimated Exposure

Cause of Death with ICD Number (a)	Maximum Level of Exposure					
	Low		Medium		High	
	Obs./Exp.	SMR (b)	Obs./Exp.	SMR (b)	Obs./Exp.	SMR (b)
All causes	361/401.84	90*	262/293.08	89	84/100.10	84
All malignancies (140-205)	65/ 71.38	98	56/ 53.47	109	18/ 16.53	112
Malignant neoplasms, buccal and pharynx (140-148)	4/ 2.60	165	1/ 1.99	52	0/ 0.60	0
Malignant neoplasms, digestive organs and peritoneum (150-159)	14/ 20.86	72	10/ 15.60	67	5/ 4.36	117
Malignant neoplasms, respiratory systems (160-164)	19/ 22.16	92	19/ 17.03	116	7/ 5.09	141
Malignant neoplasms, genital organs (170-179)	3/ 3.92	82	1/ 2.59	40	0/ .65	0
Malignant neoplasms, urinary organs (180-181)	5/ 3.50	153	3/ 2.63	119	0/ 0.71	0
Malignant neoplasms, other and unspecified sites	11/ 9.92	119	13/ 7.52	180	4/ 2.74	150
Leukemia and aleukemia (204)	5/ 3.27	164	3/ 2.36	133	1/ 1.01	101
Lymphomas (200-203, 205)	4/ 5.14	84	6/ 3.74	168	1/ 1.48	69
Major cardiovascular and renal diseases (330-334, 400-468, 592-594)	175/196.45	96	136/146.22	97	36/ 42.57	87
Cirrhosis of liver (581)	7/ 12.99	58*	7/ 9.60	76	0/ 3.85	0
All other certified causes	89/121.02	79**	52/ 83.79	65**	28/ 37.14	77
Number of workers	4,925		3,021		1,731	
Number of person-years	58,741		39,927		21,535	

a. Numbers indicate categories in the 1955 version of the International Classification of Diseases.

b. SMR's other than for "all causes" adjusted for deaths with unknown cause (i.e. missing death certificates) by factors of +7.44%, +4.382%, and +2.439% respectively;

* Significant at the 0.05 level.

** Significant at the 0.01 level.

Table 9

Standardized Mortality Ratios and Observed Deaths Due to Malignancies of the Digestive Organs and Peritoneum Among 9,677 Vinyl Chloride Workers by Duration of Exposure, Years Since Exposure Began, and Maximum Level of Exposure(a)

Interval from Beginning of Exposure to End of Study (Years)	Duration of Exposure (Years)																		Total
	1 to 4			5 to 9			10 to 14			15 to 19			20 to 24			25+			
	L ^(b)	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	
0 to 9	121 (1)	184 (1)	0 (0)	0 (0)	0 (0)	0 (0)	-	-	-	-	-	-	-	-	-	88 (1)	139 (1)	0 (0)	98 (2)
10 to 14	170 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	-	-	-	-	-	-	89 (1)	0 (0)	0 (0)	51 (1)
15 to 19	0 (0)	317 (1)	0 (0)	0 (0)	0 (0)	0 (0)	318 (2)	275 (1)	418 (1)	0 (0)	0 (0)	0 (0)	-	-	-	82 (2)	171 (2)	141 (1)	116 (5)
20 to 24	58 (1)	0 (0)	342 (1)	0 (0)	0 (0)	0 (0)	154 (1)	140 (1)	0 (0)	0 (0)	0 (0)	236 (1)	0 (0)	0 (0)	0 (0)	49 (2)	33 (1)	139 (2)	59 (5)
25+	85 (3)	0 (0)	0 (0)	79 (2)	112 (2)	0 (0)	65 (1)	57 (1)	0 (0)	59 (1)	64 (1)	388 (1)	105 (1)	80 (1)	0 (0)	75 (8)	64 (6)	115 (2)	74 (16)
Total	79 (6)	46 (2)	100 (1)	43 (2)	66 (2)	0 (0)	135 (4)	102 (3)	125 (1)	38 (1)	40 (1)	240 (2)	84 (1)	67 (1)	0 (0)	72 (14)	67 (10)	117 (5)	75 (29)

a. SMR's adjusted for deaths with unknown cause; observed deaths are given in parentheses.

b. L, M, H, = low, medium, or high based on highest exposure category reported for at least a 12-month period.

Table 10

Standardized Mortality Ratios and Observed Deaths Due to Malignancies of the Respiratory System Among 9,677 Vinyl Chloride Workers by Duration of Exposure, Years Since Exposure Began, and Maximum Level of Exposure(a) -

Interval from Beginning of Exposure to End of Study (Years)	Duration of Exposure (Years)															Total			
	1 to 4			5 to 9			10 to 14			15 to 19			20 to 24				25+		
	L ^(b)	M	H	L	M	H	L	M	H	L	M	H	L	M	H		L	M	H
0 to 9	101 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	-	-	-	-	-	-	-	-	-	72 (1)	0 (0)	0 (0)	40 (1)
10 to 14	0 (0)	734 (2)	0 (0)	208 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	-	-	-	-	-	-	72 (1)	267 (2)	0 (0)	125 (3)
15 to 19	96 (1)	0 (0)	0 (0)	0 (0)	307 (1)	0 (0)	0 (0)	220 (1)	332 (1)	0 (0)	0 (0)	0 (0)	-	-	-	35 (1)	141 (2)	118 (1)	78 (4)
20 to 24	0 (0)	0 (0)	308 (1)	341 (3)	188 (1)	0 (0)	131 (1)	119 (1)	0 (0)	110 (1)	542 (5)	185 (1)	0 (0)	353 (1)	-	107 (5)	199 (7)	176 (3)	152 (15)
25+	87 (3)	131 (3)	474 (2)	175 (4)	60 (1)	0 (0)	72 (1)	59 (1)	0 (0)	177 (3)	58 (1)	0 (0)	0 (0)	212 (1)	0 (0)	107 (11)	82 (8)	151 (3)	100 (22)
Total	63 (5)	110 (5)	278 (3)	168 (8)	97 (3)	0 (0)	64 (2)	96 (3)	108 (1)	139 (4)	204 (6)	96 (1)	0 (0)	265 (2)	0 (0)	92 (19)	116 (19)	141 (7)	107 (45)

a. SMR's adjusted for deaths with unknown cause; observed deaths are given in parentheses.

b. L, M, H, = low, medium, or high based on highest exposure category reported for at least a 12-month period.

Table 11

Standardized Mortality Ratios and Observed Deaths Due to Malignancies of the Urinary Organs Among 9,677 Vinyl Chloride Workers by Duration of Exposure, Years Since Exposure Began, and Maximum Level of Exposure(a)

Interval from Beginning of Exposure to End of Study (Years)	Duration of Exposure (Years)															Total			
	1 to 4			5 to 9			10 to 14			15 to 19			20 to 24				25+		
	L ^(b)	M	H	L	M	H	L	M	H	L	M	H	L	M	H		L	M	H
0 to 9	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	-	-	-	-	-	-	-	-	-	0 (0)	0 (0)	0 (0)	
10 to 14	0 (0)	0 (0)	0 (0)	1,567 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	-	-	-	-	-	534 (1)	0 (0)	0 (0)	
15 to 19	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2,717 (1)	0 (0)	-	-	-	0 (0)	519 (1)	0 (0)	
20 to 24	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
25+	340 (2)	505 (2)	0 (0)	240 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	337 (1)	0 (0)	0 (0)	0 (0)	0 (0)	223 (4)	125 (2)	0 (0)	
Total	159 (2)	281 (2)	0 (0)	258 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	220 (1)	228 (1)	0 (0)	0 (0)	0 (0)	0 (0)	153 (5)	119 (3)	0 (0)	
																		123 (8)	

a. SMR's adjusted for deaths with unknown cause; observed deaths are given in parentheses.

b. L, M, H, = low, medium, or high based on highest exposure category reported for at least a 12-month period.

Table 12

Standardized Mortality Ratios and Observed Deaths Due to Malignancies of Other and Unspecified Sites Among 9,677 Vinyl Chloride Workers by Duration of Exposure, Years Since Exposure Began, and Maximum Level of Exposure(a)

Interval from Beginning of Exposure to End of Study (Years)	Duration of Exposure (Years)														
	1 to 4			5 to 9			10 to 14			15 to 19			20 to 24		
	L ^(b)	M	H	L	M	H	L	M	H	L	M	H	L	M	H
0 to 9	0 (0)	0 (0)	0 (0)	491 (1)	0 (0)	0 (0)	-	-	-	-	-	-	-	116 (1)	0 (0)
10 to 14	0 (0)	0 (0)	0 (0)	419 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	-	-	-	-	142 (1)	0 (0)
15 to 19	0 (0)	913 (2)	0 (0)	0 (0)	532 (1)	0 (0)	0 (0)	0 (0)	0 (0)	864 (1)	0 (0)	0 (0)	-	72 (1)	407 (3)
20 to 24	105 (1)	220 (1)	498 (1)	0 (0)	0 (0)	0 (0)	275 (1)	0 (0)	0 (0)	268 (1)	290 (1)	429 (1)	800 (1)	177 (4)	129 (2)
25+	0 (0)	100 (1)	0 (0)	0 (0)	135 (1)	0 (0)	0 (0)	416 (3)	0 (0)	307 (2)	146 (1)	743 (1)	523 (2)	98 (4)	201 (8)
Total	25 (1)	179 (4)	130 (1)	95 (2)	131 (2)	0 (0)	74 (1)	223 (3)	0 (0)	352 (4)	175 (2)	426 (2)	591 (3)	119 (11)	180 (13)
														0 (0)	739 (2)
														0 (0)	150 (4)
														0 (0)	147 (28)

a. SMR's adjusted for deaths with unknown cause; observed deaths are given in parentheses.

b. L, M, H, = low, medium, or high based on highest exposure category reported for at least a 12-month period.

Table 14

Standardized Mortality Ratios and Observed Deaths Due to Lymphomas Among 9,677 Workers in Plants Producing Vinyl Chloride, by Duration of Exposure, Years Since Exposure Began, and Maximum Level of Exposure (a)

Interval from Beginning of Exposure to End of Study (Years)	Duration of Exposure (Years)																				
	1 to 4			5 to 9			10 to 14			15 to 19			20 to 24			25+			Total		
	L ^(b)	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	Total		
0 to 9	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	-	-	-	-	-	-	-	-	-	0 (0)	0 (0)	0 (0)	0 (0)		
10 to 14	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	-	-	-	-	-	0 (0)	0 (0)	0 (0)	0 (0)		
15 to 19	0 (0)	812 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	938 (1)	0 (0)	0 (0)	0 (0)	0 (0)	-	-	-	0 (0)	518 (2)	0 (0)	141 (2)		
20 to 24	195 (1)	0 (0)	0 (0)	426 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	172 (2)	0 (0)	0 (0)	85 (2)		
25+	134 (1)	0 (0)	0 (0)	211 (1)	0 (0)	0 (0)	0 (0)	874 (3)	0 (0)	313 (1)	1,521 (1)	0 (0)	0 (0)	0 (0)	0 (0)	97 (2)	210 (4)	218 (1)	159 (7)		
Total	94 (2)	83 (1)	0 (0)	178 (2)	0 (0)	0 (0)	0 (0)	620 (4)	0 (0)	189 (1)	439 (1)	0 (0)	0 (0)	0 (0)	0 (0)	84 (4)	168 (6)	69 (1)	112 (11)		

a. SMR's adjusted for deaths with unknown cause; observed deaths are given in parentheses.

b. L, M, H, = low, medium, or high based on highest exposure category reported for at least a 12-month period.

Table 15

Standardized Mortality Ratios and Observed Deaths Due to Major Cardiovascular and Renal Diseases Among 9,677 Vinyl Chloride Workers by Duration of Exposure, Years Since Exposure Began, and Maximum Level of Exposure(a)

Interval from Beginning of Exposure to End of Study (Years)	Duration of Exposure (Years)															Total			
	1 to 4			5 to 9			10 to 14			15 to 19			20 to 24				25+		
	L(b)	M	H	L	M	H	L	M	H	L	M	H	L	M	H		L	M	H
0 to 9	62 (5)	74 (4)	0 (0)	104 (3)	0 (0)	0 (0)	-	-	-	-	-	-	-	-	-	72 (8)	56 (4)	0 (0)	60* (12)
10 to 14	103 (6)	43 (1)	161 (1)	109 (4)	73 (2)	108 (1)	143 (2)	229 (2)	182 (1)	-	-	-	-	-	-	110 (12)	84 (5)	143 (3)	105 (20)
15 to 19	45 (4)	95 (3)	61 (1)	47 (3)	177 (5)	122 (2)	99 (6)	142 (5)	82 (2)	152 (3)	51 (1)	65 (1)	-	-	-	69 (16)	122 (14)	82 (6)	85 (36)
20 to 24	109 (18)	90 (7)	136 (4)	13 (1)	127 (6)	0 (0)	112 (7)	60 (4)	192 (6)	90 (6)	89 (6)	24 (1)	0 (0)	87 (2)	0 (0)	81 (32)	89 (25)	79 (11)	83 (68)
25+	98 (32)	86 (19)	132 (5)	104 (24)	121 (20)	33 (1)	167* (24)	91 (15)	0 (0)	108 (17)	150 (22)	202 (5)	92 (8)	70 (8)	88 (3)	64 (2)	71 (4)	100 (2)	105 (211)
Total	90 (65)	83 (34)	109 (11)	80 (35)	116 (33)	48 (4)	139 (39)	94 (26)	115 (9)	107 (26)	124 (29)	86 (7)	73 (8)	73 (10)	56 (3)	96 (175)	97 (136)	87 (36)	95 (347)

a. SMR's adjusted for deaths with unknown cause; observed deaths are given in parentheses.

b. L, M, H, = low, medium, or high based on highest exposure category reported for at least a 12-month period.

* Significant at the 0.05 level.

Table 16

Standardized Mortality Ratios and Observed Deaths Due to Cirrhosis of the Liver Among 9,677 Vinyl Chloride Workers by Duration of Exposure, Years Since Exposure Began, and Maximum Level of Exposure(a)

Interval from Beginning of Exposure to End of Study (Years)	Duration of Exposure (Years)											
	1 to 4			5 to 9			10 to 14			15 to 19		
	L(b)	M	H	L	M	H	L	M	H	L	M	H
0 to 9	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	-	-	-	-	-	-
10 to 14	183 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	-	-	-
15 to 19	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	304 (1)	0 (0)	0 (0)	-	-
20 to 24	81 (1)	165 (1)	0 (0)	0 (0)	0 (0)	0 (0)	194 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
25+	115 (2)	88 (1)	0 (0)	185 (2)	0 (0)	0 (0)	0 (0)	123 (1)	0 (0)	0 (0)	133 (1)	0 (0)
Total	78 (4)	70 (2)	0 (0)	71 (2)	0 (0)	0 (0)	54 (1)	117 (2)	0 (0)	0 (0)	116 (1)	0 (0)
										58*	76 (7)	0 (0)
												56** (14)

a. SMR's adjusted for deaths with unknown cause; observed deaths are given in parentheses.

b. L, M, H, = low, medium, or high based on highest exposure category reported for at least a 12-month period.

* Significant at the 0.05 level.

** Significant at the 0.01 level.

Table 17

Standardized Mortality Ratios and Observed Deaths Due to All Other Certified Causes Among 9,677 Vinyl Chloride Workers
by Duration of Exposure, Years Since Exposure Began, and Maximum Level of Exposure(a) -

Interval from Beginning of Exposure to End of Study (Years)	Duration of Exposure (Years)															
	1 to 4				5 to 9				10 to 14				15 to 19			
	L ^(b)	M	H	Total	L	M	H	Total	L	M	H	Total	L	M	H	Total
0 to 9	42 (5)	96 (7)	27 (1)	165 (13)	49 (1)	184 (2)	0 (0)	233 (13)	-	-	-	-	-	-	-	42** (6)
10 to 14	57 (3)	35 (1)	0 (0)	92 (4)	170 (5)	0 (0)	0 (0)	170 (5)	0 (0)	0 (0)	0 (0)	0 (0)	-	-	-	91 (8)
15 to 19	114 (8)	118 (4)	91 (3)	323 (21)	42 (2)	111 (3)	83 (2)	236 (13)	141 (5)	40 (1)	0 (0)	181 (11)	0 (0)	0 (0)	0 (0)	101 (16)
20 to 24	91 (12)	84 (5)	215 (7)	390 (24)	106 (6)	29 (1)	0 (0)	135 (7)	48 (2)	79 (3)	0 (0)	127 (11)	174 (4)	0 (0)	0 (0)	82 (22)
25+	72 (13)	64 (8)	112 (4)	248 (15)	43** (5)	55 (5)	181 (4)	279 (14)	117 (8)	105 (8)	143 (2)	365 (21)	0 (0)	73 (3)	68 (1)	0 (0)
Total	74* (41)	79 (25)	101 (15)	254 (161)	71 (19)	59* (11)	68 (6)	198 (11)	100 (15)	84 (12)	34 (2)	218 (13)	92 (9)	11 (1)	87 (4)	79** (89)
																65** (52)
																77 (28)
																74** (169)

a. SMR's adjusted for deaths with unknown cause; observed deaths are given in parentheses.

b. L, M, H, = low, medium, or high based on highest exposure category reported for at least a 12-month period.

* Significant at the 0.05 level.

** Significant at the 0.01 level.

Table 18

Observed/Expected Deaths for Selected Causes of Death in 9,677 Vinyl Chloride Workers Grouped
by Total Integrated Dose(a)

Cause of Death with ICD Number(b)	Total Integrated Dose(c)					
	12-49	50-99	100-199	200-299	300-399	400+
All Causes	167/244.9	144/164.4	167/181.0	116/119.1	53/59.1	60/69.0
All Malignancies (140-205)	28/ 38.8	29/ 26.5	26/ 30.8	26/ 21.7	9/11.0	21/13.2
Malignant neoplasms, buccal and pharynx (140-148)	3/ 1.4	2/ 1.0	0/ 1.1	0/ .8	0/ .4	0/ .5
Malignant neoplasms, digestive organs and peritoneum (150-159)	7/ 11.1	2/ 7.7	8/ 9.2	4/ 6.5	1/ 3.2	7/ 3.8
Malignant neoplasms, respiratory system (160-164)	8/ 11.4	10/ 7.9	9/ 9.4	8/ 7.0	3/ 3.7	7/ 4.6
Malignant neoplasms, genital organs (170-179)	0/ 2.1	1/ 1.5	1/ 1.6	1/ 1.1	1/ .5	0/ .5
Malignant neoplasms, urinary organs (180-181)	4/ 1.8	2/ 1.2	0/ 1.5	2/ 1.1	0/ .56	0/ .66
Malignant neoplasms, other and unspecified sites	2/ 5.8	6/ 3.8	6/ 4.4	7/ 2.9	2/ 1.0	5/ 1.8
Leukemia and aleukemia (204)	2/ 2.0	3/ 1.3	1/ 1.4	2/ .9	0/ .4	1/ .5
Lymphomas (200-03, 205)	2/ 3.16	3/ 2.1	1/ 2.2	2/ 1.4	2/ .7	1/ .8
Major cardiovascular and renal diseases (330-34, 400-68, 592-94)	71/105.8	59/ 73.3	90/ 86.69	66/ 60.7	31/30.1	30/35.1
Cirrhosis of liver (581)	3/ 7.4	4/ 5.18	2/ 5.6	1/ 3.66	3/ 1.9	1/ 2.4
All other causes	47/ 92.9	43/ 59.4	41/ 57.9	22/ 33.1	9/16.0	7/18.2
Number of Workers	2,778	2,306	2,054	1,088	536	915
Number of person-years	44,423	26,704	25,425	11,922	5,653	6,179

a. SMR's adjusted for deaths with unknown causes.

b. Numbers indicate categories in the 1955 version of the International Classification of Diseases.

c. Refer to Table 5 for total expected deaths. The total of the individual cells in Table 18 will not equal 795.02 due to rounding error.

Table 19

Standardized Mortality Ratios for Selected Causes of Death in 9,677 Vinyl Chloride Workers Grouped by Total Integrated Dose(a)

Cause of Death with ICD Number(b)	Total Integrated Dose					
	12-49	50-99	100-199	200-299	300-399	400+
All Causes		88	92	97	90	87
All Malignancies (140-205)	68**	117	89	121	83	162
Malignant neoplasms, buccal and pharynx (140-148)	244	225	0	0	0	0
Malignant neoplasms, digestive organs and peritoneum (150-159)	71	28	92	62	32	188
Malignant neoplasms, respiratory system (160-164)	79	136	101	116	83	154
Malignant neoplasms, genital organs (170-179)	0	70	65	88	193	0
Malignant neoplasms, urinary organs (180-181)	247	171	0	182	0	0
Malignant neoplasms, other and unspecified sites	39*	168	144	242	137	283
Leukemia and aleukemia (204)	111	240	75	227	0	205
Lymphomas (200-03, 205)	71	153	48	147	295	124
Major cardiovascular and renal diseases (330-34, 400-68, 592-94)	75**	86	109	110	105	87
Cirrhosis of liver (581)	45*	82	38*	27	161	42
All other causes	57**	77*	74*	67*	57*	39**
Number of Workers	2,778	2,306	2,054	1,088	536	915
Number of person-years	44,423	26,704	25,425	11,922	5,653	6,179

a. SMR's adjusted for deaths with unknown causes.

b. Numbers indicate categories in the 1955 version of the International Classification of Diseases.

* Significant at the 0.05 level.

** Significant at the 0.01 level.

Table 20

Observed and Expected Deaths and Standardized Mortality Ratios
for Selected Causes of Death Among Vinyl Chloride Workers
with Medium or High Exposures* in Plants Producing Only PVC
and Whose First Exposure to VC Began 20 or More Years Before the End of the Study

<u>Cause of Death with ICD Number</u> ¹	<u>Deaths Observed/Expected</u>	<u>SMR</u> ²
All Causes	210/249.27	84**
All malignancies (140-205)	46/ 46.04	106
Malignant neoplasms of buccal cavity and pharynx (140-148)	1/ 1.73	61
Malignant neoplasms of digestive organs and peritoneum (150-159)	9/ 13.63	70
Malignant neoplasms, respiratory system (160-164)	17/ 14.75	122
Malignant neoplasm genital organs (170-179)	1/ 2.23	47
Malignant neoplasm, urinary organs (180-181)	2/ 2.30	92
Malignant neoplasms, other and unspecified sites	10/ 6.33	167
Leukemia and aleukemia (204)	2/ 1.97	107
Lymphomas (200-203, 205)	4/ 3.10	136
Major cardiovascular and renal disease (330-334, 400-468, 592-594)	104/127.54	86
Cirrhosis of liver (581)	6/ 7.95	80
All other causes	43/ 67.74	67**

1 Numbers indicate categories in the 1955 edition of the International Classification of Disease

2 SMR's adjusted for deaths with unknown cause, i.e. no death certificate

* Significant at the 0.05 level

** Significant at the 0.01 level

Table 21
Deaths Due to Malignant Neoplasms of the Liver and Biliary Passages

Study No.	Hire Date	Date of Death	Age at Death	Months Exposed	Time-Weighted Total	Maximum Level of Exposure	Cause of Death as Given on Death Certificate (a)	Autopsy
1522	6-49	10-66	66	176	176	Low	Generalized abdominal carcinoma (2 months); carcinoma of the liver (8 months)	No
5765 ^(b)	6-44	3-68	45	167	307	Medium	Angiosarcoma right lobe of liver (10 months)	Yes
6084	4-55	7-68	65	157	157	Low	Carcinoma of liver, primary (6 months)	-
6666 ^(b)	5-50	3-69	41	50	116	High	Hemangioendothelial sarcoma of liver with metastases to lungs; cirrhosis of liver and ascites; hepatoma	Yes
7303 ^(b)	11-55	9-71	38	174	486	High	Liver failure (1 month); cancer of liver, primary (15 months)	-
7369	9-45	9-66	70	182	182	Low	Adenocarcinoma of common bile duct with liver metastasis (2 years)	No
7376 ^(b)	6-44	4-64	52	238	714	High	Cardiac tamponade and massive hemothorax; widely metastatic angiosarcoma of liver (4 months)	-
7385 ^(b)	10-49	1-68	43	214	642	High	Hepatic failure; primary carcinoma of liver	Yes
9613	11-28	12-70	67	95	95	Low	Carcinomatosis; cancer of gall bladder (6 months)	No
9671	4-41	8-65	53	213	426	Medium	Cardiac arrest; widespread cancer of gall bladder	Yes

a. Duration of illness as shown on death certificates is given in parentheses.

b. Angiosarcoma cases; study Nos. 7303 and 7385 were known from other sources to have died from angiosarcoma although not stated on the death certificate.

Table 22
Deaths Due to Malignant Neoplasms of Urinary Organs

Study No.	Hire Date	Date of Death	Age at Death	Months Exposed	Time-Weighted Total	Maximum Level of Exposure	Cause of Death as Given on Death Certificate ^(a)	Autopsy
2092	3-40	11-68	58	75	75	Low	Metastatic carcinoma of kidney, uremia (4 months); carcinoma of kidney (10 months)	No
6393	3-42	12-67	70	18	36	Medium	Uremia (2 months); carcinoma of the bladder	No
6560	1-44	11-50	59	48	48	Low	Carcinoma of bladder; carcinoma	-
6644	8-43	3-62	67	19	38	Medium	Generalized carcinomatosis; primary adenocarcinoma of left kidney (8-18 months)	No
8841	1-53	8-70	50	194	274	Medium	Pulmonary metastases (2 months); renal carcinoma (Several months)	-
9763	3-46	6-67	46	24	24	Low	Carcinoma of kidney (9 weeks)	No
A094	8-45	2-69	53	61	61	Low	Carcinomatosis, including both lungs, liver, bones, lymph nodes (few weeks); Probable primary site, hypernephroma, right	No
A312	6-31	10-66	59	208	208	Low	Metastatic (renal type) carcinoma cerebellum (6 months) and metastatic carcinoma lung (6 months); carcinoma left kidney (4 years)	

a. Duration of illness as shown on death certificates is given in parentheses.

Table 23
Deaths Due to Malignant Neoplasms of Other and Unspecified Sites

Study No.	Hire Date	Date of Death	Age at Death	Months Exposed	Time-Weighted Total	Maximum Level of Exposure	Cause of Death as Given on Death Certificate (a)	Autopsy
2096	10-40	9-72	67	69	69	Low	Brain tumor (carcinoma) (8 months) malignant	-
2744	9-53	3-69	38	186	186	Low	Widespread metastatic melanoma (1 year); melanoma of back	Yes
2850	12-44	3-71	64	193	193	Low	Carcinomatosis, primary region not known (past history rheumatoid arthritis, myocardial infarction)	No
3700	8-48	5-71	48	49	49	Low	Malignant melanoma with widespread metastases	No
3946	8-67	12-72	43	64	64	Low	Meningitis and pneumonitis (5 weeks); ependymoma, 4th ventricle - brain (2 months post-operative craniotomy)	No
4433	10-55	8-68	54	81	162	Medium	Astrocytoma, malignant left cerebral hemisphere (1 year)	Yes
4778	10-45	9-72	54	300	377	Medium	Cardiac arrest (1 hour); respiratory arrest and cerebral hypoxia (2 days); widespread metastatic carcinoma (2 months)	-
4786	5-37	11-69	61	318	529	Medium	Generalized metastasis undifferentiated (7 months); squamous cell carcinoma, primary site undetermined	Yes
4800	2-22	11-58	61	51	74	Medium	Carcinoma of the brain; arteriosclerosis; pneumonia due to static congestion	No
5246	7-47	2-71	67	201	355	High	Liposarcoma with metastasis (3 months)	Yes
5769	6-42	3-66	52	239	478	Medium	Carcinomatosis; carcinoma vertebral body	Yes

a. Duration of illness as shown on death certificates is given in parentheses.

Table 23-cont'd
Deaths Due to Malignant Neoplasms of Other and Unspecified Sites

Study No.	Hire Date	Date of Death	Age at Death	Months Exposed	Time-Weighted Total	Maximum Level of Exposure	Cause of Death as Given on Death Certificate	Autopsy
5783	9-45	5-71	69	166	217	Medium	Metastatic carcinoma of abdomen, critical site undetermined (pulmonary emphysema)	-
6339	8-50	12-72	58	25	50	Medium	Carcinoma larynx and throat	-
6578	10-45	9-72	79	60	120	Medium	Generalized carcinomatosis; carcinoma tongue-pharynx	-
6779	9-45	9-72	57	48	96	Medium	Respiratory arrest; squamous cell carcinoma of the neck (1 year)	No
6871	1-50	5-70	43	32	96	High	Glioblastoma multiforme (4 months)	No
6907	12-56	12-71	54	18	36	Medium	Astrocytoma brain (5 months)	Yes
7279	1-47	3-71	57	271	271	Low	Brain tumor; glioblastoma multiforme (18 months)	-
7300	12-45	6-63	44	211	633	High	Brain tumor, malignant (2 months)	-
7301	10-44	3-56	55	133	266	Medium	Carcinomatosis (4 months), primary site undetermined	No
7306	3-52	6-70	53	216	432	Medium	Thyroid carcinoma with metastases	No
7371	11-49	8-71	58	249	249	Low	Brain tumor, malignant	No
8838	9-47	5-71	49	271	723	High	Brain tumor, malignant (3 months)	No
8968	1-46	9-64	65	148	296	Medium	Generalized carcinomatosis (1 year)	No
9506	3-36	6-57	47	190	190	Low	Melanosarcoma; malignant mole (3 years)	No
9550	10-48	9-72	48	139	139	Low	Fibrosarcoma	No
9953	6-30	12-56	59	220	220	Low	Glioblastoma multiforme (6 months); brain abscess	Yes
A311	2-30	9-67	57	263	263	Low	Glioblastoma multiforme (brain tumor) (8 months)	No

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