

IV. EXPOSURE LEVELS

Of the 9,677 workers who were traced, 6,488 (67%) worked in plants which produced polyvinyl chloride (PVC) from vinyl chloride monomer (VCM) made elsewhere, while 3,209 (33%) worked in plants which produced VCM, with or without polymerization operations on the same site. About 1,122 of the latter or 11.6% of the total study population worked in plants which produced copolymers.

An attempt was made to estimate the relative levels of exposure to VCM by asking management and industrial hygiene personnel in each plant to classify each exposed job as having "high," "medium," or "low" exposure.

Since measurements of atmospheric concentrations of vinyl chloride had seldom been made in the past, these estimates were subjective and indicated only the relative levels of exposure within a given plant. It is quite possible that, in objective terms, a "high" in one plant might have corresponded to a "medium" in another, and that a "low" in 1950 might correspond to a "high" in 1970 in the same plant. However, it seems reasonable to assume that those jobs labelled "high" would on the average have a higher level of exposure than those labelled "medium," and that the latter in turn would on the average have a greater exposure than those labelled "low."

The estimated exposure levels of the jobs were used in two ways to characterize the exposure history of workers in the study. First, all workers were classified by their estimated maximum exposure to VCM. More specifically, they were classified by the estimated maximum level at or above which they had been exposed for at least 12 months. For example, a worker who had worked for 13 months in a "high" level job was classified as "high." If he had worked for 10 months at a "high" level job, 3 months

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at a "medium" level job, and 15 months at a "low" level job, he was classified as "medium."

Secondly, all workers were classified by their estimated integrated or cumulative exposure. A man was given a score of 1 for each month in a "low" level job, 2 for each month in a "medium" level job, and 3 for each month in a "high" level job. The total score over a worker's working life time provided a rough estimate of his cumulative exposure. It is recognized that this arbitrary scoring need not accurately reflect quantitative relationships between levels of exposure; scales of 1, 10, and 100 for low, medium, and high might have served equally well. There was, however, no factual basis for choosing an alternative scale.

The use of the two preceding exposure estimates resulted in a total of four ways of characterizing the exposure of each worker:

- (1) Duration of exposed employment
- (2) Interval from beginning of exposure to end of observation
- (3) Estimated maximum exposure over 12 months or more
- (4) Estimated integrated exposure.

In the mortality tables, cause-specific mortality will be shown for various combinations of these estimates.

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V. CALCULATIONS OF MORTALITY

The usual method of describing the risk of death in a study of this kind is to compare the number of deaths which actually occurred with the number which would have been expected in a comparable male population observed over the same age and time intervals. This comparison, expressed as a percentage, is called the Standardized Mortality Ratio (SMR). The use and limitations of the SMR has been the subject of a number of recent articles (Lloyd, 1976; Gaffey, 1976; McMichael, 1976).

Each worker in the study, i.e. every one whose vital status was ultimately known, was considered to have been under observation from the date on which he attained a year of exposed employment or from the date when his plant's records were complete, whichever came later. Observation periods ended December 31, 1972 or on the date of death, whichever occurred first.

In order to calculate the number of expected deaths, it was first necessary to calculate the number of years for which each worker was observed, and to classify these years of observation by the age intervals into which they fell and the birth date of the worker, which determined the calendar year during which a man of this age was observed.

Workers were grouped by birth date into 5-year intervals, and the number of person-years contributed by each such cohort for each 5-year age interval was calculated. Age and cause-specific mortality rates for United States males with the same birth dates, and the same ages for the years 1950, 1955, 1959, 1965, and 1970 were applied to these person-years to obtain the expected number of deaths.

The use of rates for the entire U.S. male population has the advantage that statistics are available on an annual basis, and these rates provide a

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common base-line for comparison with mortality studies in other industries and plants. While the geographical distribution of the study population might have suggested the use of regional or state standards, these standards share with U.S. standards the defect that they do not take into account differences between the total male population and the employed male population. The effect of such differences may be particularly important in states where there is a marked disparity in the standard of living between employed and unemployed, or between industrial and agricultural workers.

Observed deaths were classified by cause according to the 1955 revision of the International Classification of Disease (ICD) by an experienced nosologist. Published mortality statistics for the U.S. population before 1955 and after 1967 are classified using differing revisions of the ICD from the one used in this study. The discrepancies, however, in the classifications are quite small except for some causes in the "all other" category for deaths before 1955, and for subcategories in the "major cardiovascular and renal" category for deaths after 1967.

Deaths for which death certificates could not be obtained were assumed to have the same cause distribution as the death certificates that were obtained. The number of observed deaths for each cause was therefore inflated to adjust for the missing certificates in each table. In practice, this was done by multiplying the calculated Standardized Mortality Ratio (SMR or percentage of observed deaths relative to expected deaths) by an appropriate correction factor. For example, in Table 5 there are 707 deaths, for which death certificates could not be obtained for 38. The SMR for each known cause was therefore increased by $38/669$ or 5.68% to correct for the 38 missing certificates.

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The statistical significance of the deviation of each SMR in the study population from an expected value of 100 was tested by a method derived from Chin Leong Chiang (1961). The formula for determining the standard error of the SMR was $SE = \sqrt{\frac{100 \times SMR}{\text{No. expected deaths}}}$ which follows from the formulas presented in the foregoing paper. If an observed SMR differed from 100 by more than 1.96 standard errors, it was regarded as significant at the 5% level, if it differed by more than 2.57 standard errors, it was regarded as significant at the 1% level. In other words, the latter difference would not be expected by chance more often than one time in one hundred. SMR's based on fewer than 5 observed cases were not tested for significance.

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VI. RESULTS: STANDARDIZED MORTALITY RATIOS

A. For the Total Population

An initial analysis was made of the mortality experience of the total study population, with full recognition of the fact that it covered such a wide range of exposures and ages that some effects might have been obscured.

Table 5 shows the results during 120,203 person-years of observation in 9,677 individuals. The overall mortality, leading to an SMR of 89, is significantly lower than 100. This so-called "healthy worker effect" is commonly found in mortality studies based upon employed populations.

The SMR for "all malignancies" was 104, that for neoplasms of the digestive organs and peritoneum was 75, that for malignancies of the respiratory system was 107, that for the urinary tract was 123, that for leukemia and aleukemia was 143 and that for lymphomas was 112. None of the SMRs for malignancies was significantly greater than 100.

The SMR for major cardiovascular and renal diseases, 95, although less than 100, was higher than usually found in employed populations, which commonly show significant deficiencies in deaths due to this group of causes. It is noteworthy that cirrhosis of the liver was found to cause significantly fewer deaths than expected (SMR = 56) and also that residual deaths, from all other certified causes not listed, were significantly fewer than expected (SMR = 74).

B. For the Population Grouped by Maximum Estimated Exposure Level

Table 6 shows SMRs for the population grouped by the maximum estimated exposure level, i.e. "low," "medium," and "high." These groups contributed 58,741, 39,927, and 21,535 person-years respectively.

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The only trends suggested were those in the SMR's for "all malignancies" and for "malignant neoplasms of the respiratory organs."

There is a disproportionately small number of observed and expected deaths in workers categorized as having "high" maximum exposures when compared with those in the "low" and "medium" groups.

The number of observed/expected deaths per 100 men studied in the "high" exposure group was 4.9/5.8, with the number of observed/expected deaths per 100 man-years of observation being 0.39/0.46. Corresponding figures for the "low" exposure group were 7.3/8.2 and 0.61/0.68; those for the "medium" exposure groups were 8.7/9.7 and 0.66/0.73. This suggests that the "high" exposure group was younger during the period of observation, which is difficult to explain unless the exposure levels of men whose employment began in the 1930's and 1940's had been underestimated.

Most of the SMR's presented in Table 6 are also shown as marginal totals in Tables 7 through 17.

C. Consideration of Duration, Time of Exposure, and Maximum Exposure

In Tables 7 through 15, SMR's are arrayed with reference to the total duration of exposure to vinyl chloride, the interval since exposure began, and the maximum estimated exposure, for eleven selected causes of death. Detailed tables are not included for cancer of the buccal cavity (5 deaths) or for cancer of the genital tract (4 deaths).

Each of the tables has 60 cells over which the observed deaths can be distributed. Consequently, in the table for "all causes," there is an average of less than 12 observed deaths per cell, while for "all malignancies," the average per cell is only slightly above 2 observed deaths. For causes of particular interest, such as digestive tract cancer, respiratory tract

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cancer, cancer of other and unspecified sites, and leukemia and aleukemia, the average number of observed or expected deaths per cell would be less than one. As a result, the SMR's in the body of a table will often be either extremely high or extremely low. For example, Table 9 shows SMR's from cancer of the digestive tract. The five observed deaths in the high exposure group cannot fall into more than five cells of the table, while the 4.27 expected deaths are distributed over all of the 20 cells representing "high" exposure, with much less than one expected death in any cell. Consequently, every cell in which an observed death occurs will have a large excess mortality, while the rest of the cells show zero mortality. Interpretation of such tables must necessarily be highly tentative and they should be looked at in terms of patterns and not individual SMR's.

For no cause of death was there a convincing trend, either with respect to duration of exposure, maximum estimated exposure, or interval from onset of exposure to end of study. A possible exception is malignancies of the respiratory tract (Table 10), where SMR's for "low," "medium," and "high" maximum exposure groups were 92, 116, and 141 respectively. The SMR for this cause in men observed 20 or more years after beginning of exposure, was greater than for groups with shorter observation periods. In the absence of information on the specific smoking histories of the workers involved, or for vinyl chloride workers in general, it is impossible to consider what influence, if any, cigarette smoking might have had on the mortality pattern.

The SMR for cancers from "other and unspecified sites" (Table 12) and the SMR for lymphoma (Table 14) in men with over 15 years of observation were also slightly higher than in men with shorter exposures. In themselves, these do not warrant any conclusions.

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D. Integrated Doses

Tables 18 and 19 show observed and expected deaths and SMR's for the 13 groups of causes arrayed by estimated total integrated exposure to vinyl chloride. The "integrated dose" is the total score obtained by crediting a worker with 1 point for each month in a "low" exposure job, 2 points for each month in a "medium" exposure job, and 3 points for each month at "high" exposure. An integrated dose of 300, for example, would be given to a person who worked 25 years (300 months) at "low" exposure, or 8.3 years at "high" exposure, or 10 years at "low" exposure plus 7.5 years at "medium" exposure. It is recognized that an exposure rated as "high" was not necessarily three times as great as one rated as "low," but we have no factual basis for setting a multiplier. The effect of a "high" dose over a short time may not be the same as a "low" dose over a long period of time, and "high" doses in the distant past may be more significant in terms of current disease than more recent "high" doses. The scores, therefore, must be interpreted with caution.

The only cause for which there was a suggestive association with integrated dose was digestive tract cancer, where there was an excess mortality when the integrated dose exceeded 400, with lower mortality than expected for all lower doses. The integrated doses for the 5 known angiosarcomas were 307, 116, 486, 714, and 642.

Respiratory tract cancer, cancer of other and unspecified sites, leukemia, and lymphomas showed slight excess mortality when the integrated doses exceeded 400, but showed inconsistent mortality patterns over lower ranges.

Table 16, which shows the distribution of the 14 deaths from hepatic cirrhosis, is of particular interest. Not only is the overall SMR for this

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cause significantly low, but there is no association with maximum estimated exposure or duration of exposure and only a marginal association with the interval from beginning of exposure to end of observation.

E. Analysis of Long-term PVC Production Workers

A separate analysis was made of a group of workers who had worked only in plants which produced polyvinyl chloride, who had begun work with vinyl chloride 20 or more years before the end of the study period, and whose maximum estimated exposure had been either "medium" or "high." As shown in Table 20, the pattern of mortality was not different from either the total study population or the study population ranked by "low," "medium," and "high" exposure categories.

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VII. SELECTED GROUPS OF DEATHS

Malignancies of the digestive tract. Deaths due to malignancies of the digestive tract are of special interest because malignancies of the liver fall into this group. Details of the 10 deaths attributed to cancer of the liver and biliary passages (CD code 155) are given in Table 21. For three of these, angiosarcoma was given as the cause in the death certificate. These were case study numbers 5765, 6666, and 7376. In addition, although not so stated on the death certificates, cases 7303 and 7385 were known, from other sources, to have had angiosarcomas. Details of the 5 angiosarcoma cases are given below:

Study No.	Maximum Exposure Level	Total Integrated Dose	Duration (years)	Years from Beginning of Exposure to Date of Death
5765	Medium	307	13	23
6666	High	116	4	18
7303	High	486	14	15
7376	High	714	19	19
7385	High	642	17	18

From the foregoing information, one can locate these cases on Table 9. Four of the five were in the "high" maximum exposure category, the fifth was in the "medium" category. All were in individuals who had had 15 or more years of possible observation since beginning of exposure and all deaths occurred 15 or more years after the beginning of exposure.

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Malignant Neoplasms of Urinary Organs. Although urinary tract tumors were not in excess, detailed data on the 8 deaths from this cause are shown in Table 22.

Tumors of Brain and Other Parts of Nervous System. Table 23 summarizes information on the 28 deaths from tumors of other and unspecified sites, including 12 deaths from tumors of the brain, as opposed to 5.9 expected, giving an SMR of 203, significant at the 0.05 level. Of these, 4 are classified as glioblastoma multiforme, but only one of these 4 was definitely confirmed by autopsy, and in 2 cases, autopsy was certified as not performed. Five of the brain tumors were classified either as "malignant brain tumors" or "carcinoma of the brain", but none of these diagnoses was definitely confirmed by autopsy, and in 3 cases the absence of autopsy was certified. Of the remaining 3 brain tumors, 2 were classified as astrocytoma, both confirmed by autopsy, and one as "ependymoma of the 4th ventricle" confirmed by craniotomy.

Of the 12 brain tumors, 7 occurred in workers from plants producing only PVC, 2 were in plants producing both PVC and VC (one of which also produced copolymers), 2 were in plants producing only homopolymers or copolymers, and one was in a plant producing only VC. There was no apparent relationship with maximum exposure or total integrated exposure: 6 deaths were in individuals whose maximum level of exposure was classified as "low", while 3 each occurred in categories "medium" and "high". Five deaths were in men whose time-weighted dose was calculated as having been less than 100.

It is difficult to interpret the significance of this finding of an apparent excess of brain tumors. In the absence of definite confirmation by either autopsy or craniotomy in 8 of the 12 cases, it is quite possible that some might have been secondary brain tumors, with unrecognized primary sites, or other non-malignant space-occupying lesions in the cranial cavity. It is of interest to note that an excess of malignant brain tumors was also reported by Waxweiler, R.J. et al of NIOSH

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(Annals of the New York Academy of Science, 271:40-48, 1976) from a much smaller study (136 deaths and 12,720 person-years), confined to 4 plants with at least 15 years history of operation in the polymerization of VC. These authors reported an SMR of 329 based on only 3 deaths, all from glioblastoma multiforme, all histologically confirmed. In fact the NIOSH group claimed in this report to have identified altogether 9 histologically confirmed cases of glioblastoma multiforme in workers exposed to vinyl chloride in U.S. industry. It is difficult to say to what extent their study population overlaps that of the presently reported EEH study.

In view of all the above, further investigation of the question of malignant brain tumors in workers exposed to vinyl chloride should be pursued.

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VII. DISCUSSION

Although the present study when compared with the first study reported in 1974 increased the study size from 7,128 to 9,677 workers who were traced, the person-years of observation from 77,846 to 120,203, and the certified deaths available for analysis from 328 to 669, it did not strengthen any of the associations suggested in the initial report.

The successive additions to the population and the improved follow-up have been accompanied by a rise in the overall-cause Standardized Mortality Ratio from 75 to 89. The major change has been in the SMR for major 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 1974 report.

In the current study, the SMR's for malignancies of various specific sites are also lower than in the 1974 report. For example, the SMR for digestive tract cancer has changed from 94 to 75, that for respiratory tract cancer from 112 to 107, that for cancer of other and unspecified sites from 155 to 147. The latter included 12 cancers of the brain as shown in Table 23 and discussed on the preceding page. No conclusion can be reached as to whether or not this apparent excess is related to occupational exposure to vinyl chloride, and further investigation is desirable.

All SMR's based on more than five deaths were tested for statistical significance, and three were found to be significantly lower than 100 (see Table 5). In general, since the health of an employed population is better than that of the general United States population, these significantly small SMR's are not surprising. With the single exception of the brain tumors, already discussed above, none of the SMR's (based on more than five deaths) that exceeded 100 was significantly different from 100. Inferences

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about the association between various causes of death and occupational exposure had to be based on the occurrence of excess mortality that increased as one or more measures of exposure increased.

There is less support for the hypothesis that vinyl chloride is a "weak general carcinogen" than there was in the report by Tabershaw & Gaffey (1974). However, based on the observation that lung cancer (uncorrected for smoking) and miscellaneous cancers are still slightly higher in individuals with higher maximum exposures, higher integrated exposures, and in those with longer periods of possible latency, weak carcinogenic action in a number of sites must still be considered. Fox and Collier (1977), in a recently reported study from Great Britain, found no evidence to support the hypothesis that cancers other than those of the liver are associated with exposure to vinyl chloride monomer.

An unexpected finding was the relatively high ratio of deaths attributed to cardiovascular and renal disease. There were no apparent relationships with duration or intensity of exposure, and there is no basis for relating this to vinyl chloride per se.

When considering this study in the context of previous reports involving part of the same population, it should be stressed that the successive reports do not represent different studies. The mortality experience of the population that was included in the 1974 report strongly influenced the final results; thus, this should not be regarded as an independent study that confirmed the previous one. The fact that many of the site-specific cancer ratios were lower than those in the initial study can represent either a refining of rates by an increase in number of person-years and number of deaths, or could reflect a different exposure experience in the populations that were added.

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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

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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.

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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

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Table 2
Distribution of Vinyl Chloride Plants and Vinyl Chloride Workers
by Census Regions and Geographic Divisions

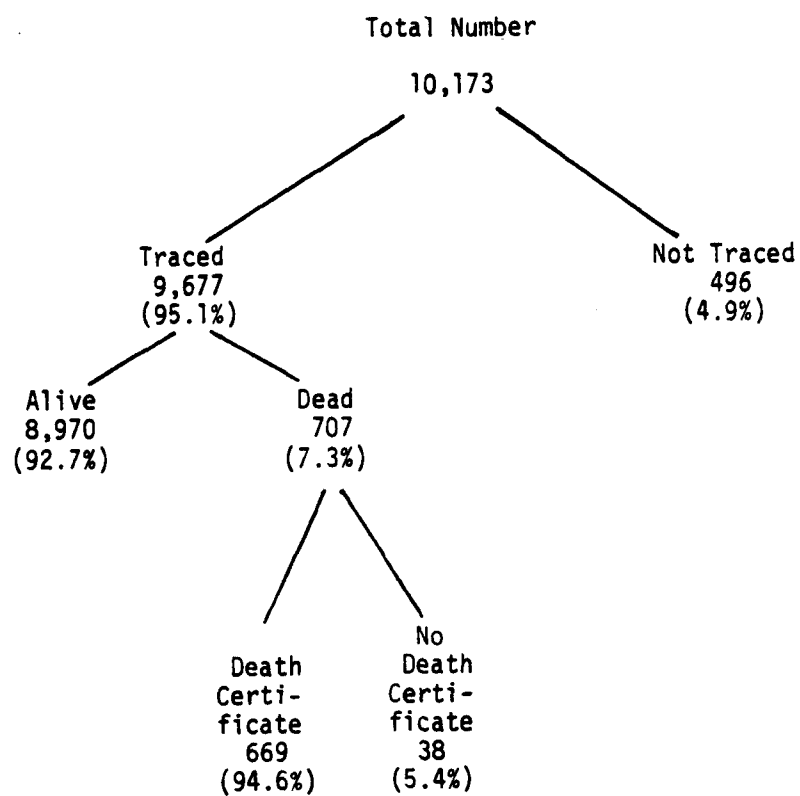
Region	Geographic Division	Percent of U.S. male Population (1970)	Number of Plants in Study	Number of Workers in Study	Number Traced
All regions		100.0	37	10,173	9,677
Northeast		23.8	8	1,619	1,550
	New England	5.8	2	467	453
	Middle Atlantic	18.0	6	1,152	1,097
North Central		27.9	6	1,872	1,817
	East 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

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Table 3

Follow-up



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Table 4

Distribution of 9,677 Vinyl Chloride Workers by Duration of Exposure
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
Total	9,677	4,384	2,339	946	1,007	17
0-9	4,193	2,720	1,473	0	0	0
10-14	931	305	228	398	0	0
15-19	1,323	352	164	208	599	0
20-24	1,525	489	192	149	196	9
25+	1,705	518	282	191	212	8
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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.

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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.

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Table 7
Standardized Mortality Ratios and Observed Deaths Due to All 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)															Total
	1 to 4			5 to 9			10 to 14			15 to 19			20 to 24			Total
	L ^(b)	M	H	L	M	H	L	M	H	L	M	H	L	M	H	
0 to 9	49** (14)	77 (12)	17 (1)	92 (6)	53 (2)	0 (0)	-	-	-	-	-	-	-	-	-	56** (35)
10 to 14	86 (12)	62 (4)	94 (2)	142 (12)	31 (2)	40 (1)	75 (2)	118 (2)	102 (1)	-	-	-	-	-	-	84 (38)
15 to 19	75 (16)	136 (11)	68 (4)	36** (5)	145 (10)	82 (4)	104 (13)	129 (10)	66 (4)	143 (5)	58 (2)	32 (1)	-	-	-	87 (85)
20 to 24	97 (38)	81 (15)	184 (15)	71 (13)	87 (10)	0 (0)	98 (13)	67 (9)	92 (7)	70 (9)	104 (13)	96 (8)	51 (2)	55 (2)	60 (2)	87 (156)
25+	88 (67)	81 (39)	121 (11)	99 (49)	90 (31)	76 (5)	128 (35)	108 (35)	50 (2)	114 (33)	107 (29)	157 (8)	98 (15)	68 (15)	78 (5)	96 (393)
Total	82** (147)	84 (81)	107 (33)	88 (85)	88 (55)	48** (10)	113 (63)	101 (56)	75 (14)	104 (47)	102 (44)	103 (17)	88 (17)	66* (17)	72 (7)	89** (707)

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.

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Table 8

Standardized Mortality Ratios and Observed Deaths Due to Malignancies 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	57 (2)	43 (1)	0 (0)	164 (2)	0 (0)	0 (0)	-	-	-	-	-	-	-	-	-	84 (4)	33 (1)	0 (0)	58 (5)
10 to 14	88 (2)	209 (2)	368 (1)	205 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	-	-	-	-	-	116 (5)	83 (2)	114 (1)	105 (8)
15 to 19	89 (3)	328 (4)	0 (0)	0 (0)	184 (2)	0 (0)	86 (2)	220 (3)	208 (2)	128 (1)	127 (1)	0 (0)	-	-	-	67 (6)	224 (10)	68 (2)	110 (18)
20 to 24	77 (5)	32 (1)	247 (3)	159 (5)	103 (2)	0 (0)	128 (3)	80 (2)	0 (0)	78 (2)	231 (6)	193 (3)	112 (1)	0 (0)	260 (2)	108 (16)	104 (11)	150 (8)	114 (35)
25+	79 (9)	92 (7)	141 (2)	155 (12)	71 (4)	0 (0)	42 (2)	160 (9)	0 (0)	148 (8)	95 (5)	334 (3)	95 (3)	47 (2)	77 (1)	0 (0)	228 (5)	126 (1)	104 (73)
Total	79 (21)	99 (15)	146 (6)	140 (22)	78 (8)	0 (0)	70 (7)	143 (14)	68 (2)	126 (11)	139 (12)	196 (6)	99 (4)	36 (2)	145 (3)	98 (65)	109 (56)	111 (18)	104 (139)

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.

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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)

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 : 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)	-	-	-	-	-	-	-	-	-	-	72 (1)	0 (0)	0 (0)	40 (1)
10 to 14	0 (0)	734 (2)	0 (0)	0 (0)	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)	307 (1)	0 (0)	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)	188 (1)	0 (0)	0 (0)	131 (1)	119 (1)	0 (0)	110 (1)	542 (5)	185 (1)	0 (0)	0 (0)	353 (1)	-	107 (5)	199 (7)	176 (3)	152 (15)
25+	87 (3)	131 (3)	474 (2)	60 (1)	0 (0)	0 (0)	72 (1)	59 (1)	0 (0)	177 (3)	58 (1)	0 (0)	0 (0)	0 (0)	212 (1)	0 (0)	251 (2)	0 (0)	151 (3)	100 (22)
Total	63 (5)	110 (5)	278 (3)	97 (3)	0 (0)	0 (0)	64 (2)	96 (3)	108 (1)	139 (4)	204 (6)	96 (1)	0 (0)	0 (0)	265 (2)	0 (0)	251 (2)	0 (0)	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 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			Total
	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)	-	-	-	-	-	-	0 (0)
10 to 14	0 (0)	0 (0)	0 (0)	1,567 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	-	-	-	309 (1)
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)	140 (1)
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)
25+	340 (2)	505 (2)	0 (0)	240 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	337 (1)	0 (0)	0 (0)	163 (6)
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)	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.

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)

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 13
Standardized Mortality Ratios and Observed Deaths Due to Leukemia and Aleukemia 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)	1,542 (1)	0 (0)	0 (0)	-	-	-	-	-	-	-	-	-	326 (1)	0 (0)	0 (0)	174 (1)
10 to 14	0 (0)	0 (0)	4,684 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	-	-	-	-	-	0 (0)	0 (0)	1,867 (1)	249 (1)
15 to 19	579 (1)	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)	237 (1)	0 (0)	0 (0)	104 (1)
20 to 24	306 (1)	0 (0)	0 (0)	0 (0)	1,137 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	140 (1)	215 (1)	0 (0)	138 (2)
25+	0 (0)	0 (0)	0 (0)	612 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	493 (1)	0 (0)	663 (1)	0 (0)	0 (0)	144 (2)	159 (2)	0 (0)	137 (4)
Total	148 (2)	0 (0)	341 (1)	417 (3)	204 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	305 (1)	0 (0)	551 (1)	0 (0)	0 (0)	164 (5)	133 (3)	101 (1)	143 (9)

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

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)															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)	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)
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)
25+	134 (1)	0 (0)	0 (0)	211 (1)	0 (0)	0 (0)	0 (0)	874 (3)	0 (0)	0 (0)	1,521 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	210 (4)	218 (1)
Total	94 (2)	83 (1)	0 (0)	178 (2)	0 (0)	0 (0)	0 (0)	620 (4)	0 (0)	0 (0)	189 (1)	439 (1)	0 (0)	0 (0)	0 (0)	0 (0)	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.

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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)																					
	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	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)	88 (3)	70 (8)	71 (4)	100 (2)	109 (107)	101 (88)	97 (16)	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)	56 (3)	73 (8)	71 (4)	100 (2)	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.
c. 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)																		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	183 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	-	-	-	-	-	-	96 (1)	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)	0 (0)	0 (0)	-	-	-	-	0 (0)	93 (1)	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)	216 (1)	0 (0)	0 (0)	0 (0)	0 (0)	-	65 (2)	95 (2)	0 (0)
25+	115 (2)	88 (1)	0 (0)	185 (2)	0 (0)	0 (0)	0 (0)	123 (1)	0 (0)	0 (0)	118 (1)	0 (0)	0 (0)	133 (1)	0 (0)	0 (0)	82 (4)	86 (4)	0 (0)
Total	78 (4)	70 (2)	0 (0)	71 (2)	0 (0)	0 (0)	54 (1)	117 (2)	0 (0)	0 (0)	134 (2)	0 (0)	0 (0)	116 (1)	0 (0)	0 (0)	58* (7)	76 (7)	0 (0)

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.

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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	49 (1)	184 (2)	0 (0)	165	-	-	-	-	-	-	-	42** (6)
10 to 14	57 (3)	35 (1)	0 (0)	92	170 (5)	0 (0)	0 (0)	170	0 (0)	0 (0)	0 (0)	0	-	-	-	91 (8)
15 to 19	114 (8)	118 (4)	91 (3)	323	42 (2)	171 (3)	83 (2)	296	141 (5)	40 (1)	0 (0)	181	183 (1)	0 (0)	0 (0)	101 (16)
20 to 24	91 (12)	84 (5)	215 (7)	510	106 (6)	29 (1)	0 (0)	135	48 (2)	79 (3)	0 (0)	127	33 (1)	0 (0)	174 (4)	82 (22)
25+	72 (13)	64 (8)	112 (4)	248	43** (5)	55 (5)	181 (4)	289	117 (8)	105 (8)	143 (2)	365	112 (7)	16 (1)	0 (0)	78 (37)
Total	74** (41)	79 (25)	101 (15)	254	71 (19)	59* (11)	68 (6)	198	100 (15)	84 (12)	34 (2)	218	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	20-299	300-399	400+
All Causes	167/244.9	144/164.4	167/181.0	15/119.1	53/59.1	60/69.0
All Malignancies (140-205)	28/ 38.8	29/ 26.5	26/ 30.8	5/ 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	1/ 6.5	1/ 3.2	7/ 3.8
Malignant neoplasms, respiratory system (160-164)	8/ 11.4	10/ 7.9	9/ 9.4	3/ 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	1/ 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	5/ 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	2/ 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	1,922	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	68**	88	92	97	90	87
All Malignancies (140-205)	81	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 Death¹ with ICD Number</u>	<u>Deaths Observed/Expected</u>	<u>SMR²</u>
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

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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)	Aopsy
1522	6-49	10-66	66	176	176	Low	Generalized abdominal carcinoma (2 months); carcinoma of the liver (8 months)	0
5765 ^(b)	6-44	3-68	45	167	307	Medium	Angiosarcoma right lobe of liver (10 months)	es
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	es
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)	0
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	es
9613	11-28	12-70	67	95	95	Low	Carcinomatosis; cancer of gall bladder (6 months)	lo
9671	4-41	8-65	53	213	426	Medium	Cardiac arrest; widespread cancer of gall bladder	es

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.

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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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