

Mortality Among Employees of PVC Fabricators

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A cross-sectional mortality study of 4,341 deaths occurring among current and former employees of 17 PVC fabricators during 1964-1973 is presented. The objectives are: (1) to identify any angiosarcoma deaths among the employees of these fabricators, and (2) to examine the distribution of deaths by cause. No angiosarcoma deaths were found among the study group. Sex-race-cause-specific Proportionate Mortality Ratios (PMR's) were computed, using the corresponding U.S. mortality as the standard. Among white employees, there appears to be an excess in total cancer mortality, particularly that of the digestive system. Observed deaths were found to exceed the expected in cancers of the breast and urinary organs among white females. Deficit mortality was observed in cirrhosis of liver among both male and female white employees.

The January 1974 disclosure of three deaths from angiosarcoma of the liver in a single vinyl chloride polymerization plant and the attention focused on this new occupational disease are well known. A significant amount of information from animal experimentation and observation on humans engaged in the production of vinyl chloride followed.¹ However, there was no information regarding the possible adverse effects on employees engaged in polyvinyl chloride (PVC) fabrication, where potential exposures were thought to be low and to result from the release of unreacted monomer trapped in the resin. This issue was considered of great import because of the very large number of workers believed to be engaged in fabrication.

In March 1974, representatives of PVC producers, who are members of the Organization Resources Counselors (ORC), Occupational Safety and Health Standards Group, contacted ORC about the feasibility of a study of health risks to employees working with vinyl chloride and polyvinyl chloride. Since the National Institute for Occupational Safety and Health (NIOSH) was conducting a study of vinyl chloride and resin producing employees, the scope of the proposed ORC study was limited to employees of

companies engaged in the fabrication of PVC resin into finished products. A number of alternative study designs was considered, and it was decided that a proportional mortality study would best meet the urgent need for information. The study concentrated on deaths occurring during the ten-year period 1964-1973 among active fabricating employees plus retirees. Since it was not possible to identify those employees with only vinyl chloride exposure, the study focused on deceased employees who worked anywhere in those plants where PVC fabrication was carried on. The primary objective of the study was to determine whether or not any angiosarcoma deaths had occurred among employees of the fabricators under study. A secondary objective was to examine the distribution of all deaths by cause.

The relatively few producers of vinyl chloride monomer and of PVC resin are generally medium to large companies. PVC fabricators, however, range from large plants of major companies to very small job shops. Even in a large plant, there may be few employees who are in the vicinity of PVC resins. The range of company plant size and number of exposed employees help to explain the wide range of estimates of total employment dependent upon PVC resins. Fabrication is geographically disbursed, with at least some operation in almost every state. Typical fabrication products include coated wire, upholstery fabrics, floor and wall coverings, pipe and other construction materials, toys, recreational equipment, phonograph records, containers and container lining, and a myriad of novelty items. Since the fabrication of PVC resin into finished products is often a part of diversified product lines in a plant, raw materials other than resin are utilized. Thus, employees may be exposed to toxic agents other than vinyl chloride. Consequently, in the current study, it is not possible to isolate only the effect of vinyl chloride. Some departures from expectation may be due to exposures to vinyl chloride, to one or more other agents, to some combination, or to employee characteristics other than occupation.

Materials and Methods

The decision to focus on a cross-sectional mortality study rather than on an historical cohort study derived from several considerations. First, the primary study objective was to determine relatively quickly whether or not any angiosarcoma deaths could be identified among the study group, and this was best accomplished by examining causes of death among relatively recent

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(i.e., past ten years) decedents. The desirability of identifying an historical cohort for follow-up was recognized, but it was determined that it would not be possible to identify clearly and completely the necessary cohort of workers within a reasonable period of time, if at all. As a consequence, this study is based upon 4,341

aths which occurred during the period 1964-1973 among current or former employees of 17 companies engaged in PVC fabrication. A total of 55 plants supplied data on all identifiable deaths since, as was mentioned earlier, it was not possible to identify those employees with only vinyl chloride exposure for the study.

In order to be included in this study, a deceased employee fell into one of the following categories: (1) employee died while actively employed, (2) employee died after retiring from the company with retirement benefits, and (3) employee died after terminating employment but with vesting in a company-sponsored life insurance plan. Deaths occurring among former employees with less than the number of years necessary for insurance vesting were not included in plant records and were, therefore, not available for this study.

An attempt was made to compensate for at least some of the "leakage" due to employees leaving the industry prior to the time they were vested in any insurance program by using the following procedures. Once death records for a given company were identified, death certificates were obtained and separated into two groups as follows: (1) all deaths with cancer (ICDA 140-205 up to 1967; ICDA 140-209 for 1968 on), or liver disease (ICDA 580-586 up to 1967; ICDA 570-576 for 1968 on), or suspected liver condition mentioned on the death certificate; and (2) all deaths from causes other than cancer or liver disease. Death records mentioning cancer or liver disease and giving a hospital as place of death were segregated and sorted by hospital. Where there were several death records for a single hospital or several hospitals in the same area, arrangements were made for a Registered Records Administrator (RRA) to visit the hospitals, review medical records, contact the hospital pathologist and review pathology records to determine whether there were any angiosarcoma cases in the hospital's pathology records. If so, an attempt was made to determine whether or not the angiosarcoma possibly could be related to vinyl chloride exposure. This procedure enabled us to identify whether any employees, who had left the industry prior to vesting in an insurance program and remained in the local area, had died from angiosarcoma of the liver. The hospital inquiry procedures turned up five deaths from angiosarcoma of the liver, according to company employment records, none were employed at any time in PVC fabricating plants. These deaths were reported to OSHA, NIOSH, and CDC for inclusion in the nationwide angiosarcoma survey.

Death certificates not mentioning a hospital as a place of death required an additional step to determine whether death occurred in a hospital or if a recent hospitalization had occurred prior to death. The certifying physician was queried by mail for information on recent hospitalization of the decedent and whether there was any indication that he or she had cancer or liver disease. Additionally identified hospitals were contacted as above.

Originally, it was planned that death certificates would be obtained from life insurance carriers. In practice, both company and life insurance records were used because of record retention practices and retrieval problems in the insurance carriers. All available death certificates were examined by a trained nosologist for mention of angiosarcoma anywhere on the certificate, and no angiosarcomas were found on the death certificates. Underlying cause

of death was classified according to the eighth revision of the International Classification of Diseases.⁷

Over the ten-year period under study, plant size was known to have changed drastically in many cases. In one instance a plant employing 300 employees in 1973 employed fewer than 100 in 1964. At the other extreme, one plant employing 5,000 employees in 1964 had only 2,000 in 1973. Some companies had gone out of business. Such developments show not only the rapid change taking place but also the difficulty of determining average industry employment. The 17 companies covered in this report range from single plant, small companies (one with 70 employees) to multiplant large companies (one with over 7,000 employees). Average number of employees clustered between 300 and 500. Although total employment is difficult to determine precisely, it is estimated to have been between 65,000 and 70,000 at the end of 1973.

Since the population at risk could not be determined, mortality rates as measures of risk could not be calculated. Rather, deaths were summarized in terms of Proportionate Mortality Ratios (PMRs) adjusted for the age distribution of the study group. The PMR is the relative frequencies of specific causes of death by age in a comparison population to obtain expected numbers of deaths from that cause in the study population. Selection of an appropriate comparison population poses some difficulties since it would be desirable to have a cause of death distribution for a similar group of workers dying during the same period, but not subjected to the factor under study. But such a comparison population was not available, and the study used mortality for the United States, specific for color and sex, for comparative purposes. Despite recognized deficiencies, the PMR can provide clues on underlying distributions of causes of death where true rates cannot be calculated.

Results

Table 1 gives the distribution of deaths among the employees of the 17 PVC fabricators within each of the ten years. An increase in the proportion of deaths taking place in later years of the decade may reflect a variety of factors, such as an increasing employee population, less complete availability of records for earlier years (e.g., in one company, there were no records for the first four of the ten years), increase in duration of exposure, etc. However, there is no reason to believe that any unavailable death records in earlier years would be concentrated in a few causes and thus bias the distribution of deaths for those years.

Table 1. — Distribution of Deaths Among Employees of 17 PVC Fabricators by Year of Death, 1964-1973.

Year of Death	No.	%
1964	325	7.5
1965	345	8.0
1966	400	9.2
1967	429	9.9
1968	499	11.5
1969	449	10.3
1970	465	10.7
1971	471	10.9
1972	528	12.2
1973	430	9.9
Total	4341	100

Table

Total	
Male	
Female	
Age	
Occupation	

The distribution given in Table 1 shows that the majority of deaths (56%) were among those aged 45-54 years, with a peak in the 45-49 age group. The distribution of deaths by age group is similar to that of the general population, but the proportion of deaths in the 45-49 age group is slightly higher (57% vs. 54%). The distribution of deaths by race is also similar to that of the general population, with a slightly higher proportion of deaths among whites (57% vs. 54%).

Table

Total	
Male	
Female	
Age	
Occupation	

Table 6. — Observed and Expected Deaths for Selected Causes Among Employees of 17 PVC Fabricators by Sex, White Only, 1964-1973.

Cause of Death	ICDA 8th Rev.	Male			Female		
		Observed	Expected	PMR*	Observed	Expected	PMR*
ALL CAUSE CANCERS	140-209	666	561 997	1.19	181	137 699	1.31
Oral Cavity and Pharynx	140-149	15	16 875	0.89	3	1 896	1.58
Digestive System	150-159	209	162 143	1.29	53	35 342	1.50
Stomach	151	41	31 507	1.30	8	4 981	1.61
Intestine	153	73	52 528	1.39	24	15 344	1.56
Rectum	154	25	19 631	1.27	8	3 877	2.06
Liver	155	6	4 190	1.43	0	0 633	—
Respiratory System	160-163	205	176 657	1.16	12	11 888	1.00
Lung	162	193	165 566	1.17	12	11 224	1.07
Bone, Connective Tissue, Skin, Breast	170-174	24	15 117	1.59	51	35 661	1.43
Breast	174	0	—	—	44	32 397	1.36
Genital Organs	180-187	44	52 828	0.83	19	23 297	0.82
Urinary Organs	188-189	36	33 131	1.09	11	4 537	2.42
Brain & Other Nervous System	191-192	16	13 885	1.15	4	3 499	1.14
Other & Unspecified	190, 193-199	56	34 607	1.62	18	9 622	1.87
Lymphomas	200-203	42	32 382	1.30	9	7 631	1.18
Leukemias	204-207	19	23 364	0.81	1	5 005	0.20
Diabetes	250	42	49 600	0.85	11	15 436	0.71
Diseases of the Circulatory System	390-458	1931	1832 515	1.05	281	309 232	0.91
Coronary Artery Disease	430-438	289	252 074	0.99	66	71 965	0.92
Coroniosclerosis	571	42	62 821	0.67	3	12 343	0.24
Cholelithiasis, Cholecystitis, and Cholangitis	574-575	7	6 349	1.10	3	1 783	1.68
Accidents, Poisoning, and Violence	E800-E999	188	265 548	0.71	48	40 855	1.17
Accidents	E800-E949	134	189 268	0.71	38	27 931	1.36
Suicide	E950-E959	40	52 375	0.76	2	9 171	0.22

* PMR is the ratio of observed to expected where the expected number is calculated on the basis of the distribution of deaths for the total U.S. in 1968 specific for color, sex, cause, and age.

occurred among employees of the PVC fabricators under study. Since no angiosarcoma deaths were found among the employees studied, the first question has an unequivocal answer. A secondary objective was that of examining the distribution of deaths by cause among the employees under study. Implicit in that objective is the question of whether or not that distribution is, in some sense, unusual. There is no unequivocal answer to the latter question. Whether or not an observed distribution of causes of death is unusual clearly relates to the standard or comparison population as well as the analytic methodology.⁶

On the basis of a proportionate mortality analysis, there appear to be excesses in total cancer mortality among both white men and white women in the study, when compared to the distributions of deaths for the total United States specific for color and sex and adjusted for age. Excesses in cancer mortality appear concentrated in cancers of the digestive system and, in particular, in cancers of the intestine for both men and women. In addition, there is a suggestion that mortality from cancer of the breast and urinary organs among white women employees is higher than that for the total U.S. There are, however, several reasons why

definitive interpretation is difficult. It has, for example, been suggested that a Proportionate Mortality Ratio based on an external population may not be sufficiently discriminating in screening for potential hazards.⁵ In addition, an analysis using PMRs fails to take account of the absolute risk of dying in the population under study.⁶ Further, a number of studies have suggested an overall favorable mortality for industrial working populations, even in those where well-defined hazards increase risk for a specific cause.⁷⁻⁹ Factors such as these are meant to suggest that proportionate mortality analysis must be interpreted cautiously, with the intention of providing leads for further investigation.

Results consistent with those of previously published studies would be of particular interest. With no comparable working populations in the fabrication industry, potential contrasts may be found in studies of vinyl chloride workers. Monson, et al, provided a proportionate mortality analysis of 161 deceased workers (all presumably white males) in two plants, one where vinyl chloride monomer is produced and one where it is polymerized into polyvinyl chloride.⁶ Results of that study suggest a possible excess in total cancer mortality, primarily cancer of the

liver. However, there was a suggestion that cancers of the lung and brain also appeared with excess frequency. The current study, while suggesting an excess in total cancer, particularly digestive cancer, does not clearly point to marked excesses for cancers of the liver, lung, and brain among white men, although the PMRs for these cancers are greater than one. The observed-to-expected PMRs reported by Monson for vascular lesions affecting the central nervous system, circulatory diseases, and external causes are similar to those reported here.

Tabershaw and Caffey, in a study of workers engaged in the manufacture of vinyl chloride and its polymers, conclude that no specific cause of death was statistically significantly greater than expectations based upon Standardized Mortality Ratios (SMRs) using the U.S. male population as the standard.⁹ By other criteria, however, the authors conclude there may be an excess risk for mortality from digestive cancer, respiratory cancer, cancer of other and unspecified sites, and lymphomas. At lower exposure levels, they suggest some excess for cancers of the buccal cavity and cancers of the other and unspecified sites.

The current study would seem to indicate that excesses of mortality from cancer of the digestive system are not sex-specific and are not limited to liver cancer. The majority of the PMRs for cancer among both white men and white women are in excess of unity. Such results must be interpreted with caution but, since they appear to be consistent with previously studied workers, they suggest the need for continued investigation.

Summary

Results of a study of 4,341 deaths occurring among current and former employees of 17 PVC fabricators during the period 1964-1973 are presented. The study was carried out to determine whether any angiosarcoma deaths had occurred among employees of these fabricators and to examine the distribution of deaths by cause. No angiosarcoma deaths were found among the study population. Distributions by cause of death among white male and white female employees were compared with those for

the entire U.S., specific for color and sex and adjusted for age means of Proportionate Mortality Ratios. There appears to be an important excess in total cancer mortality among both white male and white female employees with digestive cancer, particularly that of the intestine, contributing to the excess. Among women employees, cancers of the breast and urinary organs also be in excess. No excesses were found for diseases of the circulatory system. There were deficits in mortality from cirrhosis of the liver among both male and female employees and a deficit in deaths from accidents, poisonings, and violence among men. The use of the Proportionate Mortality Ratio based on an external standard requires caution in interpreting these results, but the need for further investigations is indicated.

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Introduction

The concept of a means of up to 1930's, the American lines for the certificate of re-employment. In 1941 of the standards to include for several years interest in the standards were still occupational largely in the appreciate the After several professional Health and Safety standards finally est granted OHI new standard the staff of U. With these OHSPAC and vice. While Industrial Hygiene be economic charges to be licent to con tions. Some for accredita of the effort Although expended, Interpretation occupational The docum criteria for Medical, N

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