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T R A N S L A T I O N

VINYL CHLORIDE EXPOSURE AND MORTALITY OF GERMAN CHEMICAL INDUSTRY WORKERS COMPARED TO THE MORTALITY OF NON-EXPOSED CHEMICAL INDUSTRY WORKERS AND PVC WORKERS

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1. Introduction

In 1974, Creech and Johnson reported their observations on three hemangiosarcomas of the liver in workers of the US polyvinyl chloride (PVC) industry. In the same year, two cases of liver angiosarcoma were determined in a PVC plant in West Germany. Meanwhile, 18 workers of the PVC industry in West Germany have died as result of this disease, another patient with hemangiosarcoma of the liver is still alive. Worldwide 85 cases were reported up to May 1980 (information on the occurrence of this disease in the USSR and in China is, however,not available).

The results of animal experiment investigations by Viola et al (1971) and Maltoni et al (1974) indicated a carcinogenic potential of vinyl chloride monomer (VCM). These investigations demonstrated the occurrence of malignomas in various organs and in rats, among other, the presence of liver angiosarcomas already at relatively low concentration of the breathed-in air.

Finally, since 1972, 165 cases of disease as a result of VCM had been reported in the Federal Republic of Germany. Until September 30, 1980, this number had increased to 320 of which 106 cases were acknowledged to be work-related.

These findings justify an epidemiological investigation to explain a disease and mortality risk in workers of the chemical industry possibly produced by exposure to VCM.

The investigations described in the following were instigated by the Minister for Work, Health and Social well-being of Nordrhein-Westfalen in agreement with the Federal Minister for Work and Social well-being and the Professional Organization of the Chemical Industry.

The investigations were conducted in cooperation with company physicians of the related companies.

It was not possible to include a parameter for the intensity of the exposure in the investigation since continuous measurements of the VC concentration in the work place are of a recent date and an auxiliary usable variable to estimate the concentration was not available.

Before 1972, sufficiently sensitive methods for systematic measurements in most plants were not available. Aside from this, the measurements were first conducted for protection against explosion.

The data acquisition took place on uniform data sheets by the company physicians of the individual plants. To process this work, inexperienced personnel was used which first led to a number of documentation errors which could be rectified by repeated checking.

The authorized registration offices provided the addresses resp. place of death for workers who left work in the plant before December 31, 1974. The death certificate had to be obtained via the authorized health department for deceased workers. To an extent, this was difficult since in some health departments death certificates are destroyed 5 years after death as permitted by law. In these cases, an effort was made to determine the cause of death in a different manner, for example, through the attending physician. In other cases, the evaluation of available death certificates first appeared impossible since according to a correct interpretation of the Federal Statistics Law, some health departments treat the medical part of the death certificate as confidential.

As a result of the intervention by the Minister for Work, Health and Social well-being of Nordrhein-Westfalen, an evaluation of these documents with correct linkage was possible while maintaining partial anonymity. The causes of death were processed under observation of the signed regulations of the International Classification of Diseases 8. This method was also used for causes of death when death occurred before 1968.

For the total mortality and some specific causes of death, mortality rates for the male population of the Federal Republic were calculated in age classifications of five years.

In order to determine a mortality risk in a certain population in one calendar year, two data are needed: the size of the population, in other words, the number of people who might have died in that year (= population at risk) and the number of people who actually died in that year. By dividing the number of deceased people by the number of all people, the mortality risk is obtained. Since the mortality risk differs in various age groups and generations, the risks are determined separately according to generations in five year age classes. A method for analyzing the suspected higher mortality which might have been caused by a chemical substance resides in comparing the mortality risk of one group of people (cohort)

exposed to this substance with the mortality risk of the entire population. This comparison can of course only be made between the corresponding age groups of the total population and the investigated cohorts. Since the mortality risk changes over the years, such a comparison must also take place by calendar year. For example, when it is known from the mortality statistics of the total population that in 1968 from the age class of 30 to 35 year old men, 8 of 1000 died of a certain cause of death and the cohorts to be investigated in the corresponding age class for the total year comprised 500 men, it could be expected that 4 of these 500 men would have died during the year of the same cause of death when the mortality risk would be identical to the risk of the total population. The number of deaths to be expected is called "expectation value". In order to determine the expectation value, it must first be determined how many people in the related year were included in the appropriate age class, for example, the class of 30 to 35 year old men (= person years). If it is demonstrated that the death of more people was observed (= observation value) than could be expected by assuming an identical risk, the mortality risk is increased. The standardized mortality risk (SMR) expresses the level of the mortality risk of the investigated cohorts compared to the same age population (risk = 100). An SMR of 130, therefore, shows a 30 % increased risk compared to the total population.

In order to calculate the person years in five year age classes, only German and Austrian nationality workers were used from the worker population since cause of death statistics of other European nations were not available in sufficient detail. The determination of cause of death in these countries, moreover, appeared to be difficult for organizational reasons. Expectation values for the total mortality in the individual age classes were calculated based on the mortality rates of the corresponding calendar years. For the specific mortality rates, the rates of 1968 were used for all calendar years up to 1968, for all later calendar years, however, the rates of the corresponding years since encoding of the causes of death in the Federal Republic before 1968 was not conducted according to the International Classification of Diseases and Causes of Death (ICD) but according to a specific German system (DAS). This procedure for causes of death with a rising tendency could have led to an overestimation of the expectation values for 1968 and consequently, too tendential, to low standardized mortality rates (SMR). This procedure seemed, however, justified since otherwise a comparability of the SMR from later years would have caused problems.

In order to consider the percentage of deaths having causes of death which could no longer be established in the calculation of the SMR for specific causes of death, the observed cases having specific causes of death were weighted analogously to the percentage of unexplainable causes of death to all causes of death.

Since the intent in this case was not the explanation of the possibly increased risk of a single disease (hemangiosarcoma of the liver) but the suspicion that an increased tumor risk existed, the possibility of conducting a case-control study was eliminated in advance. Such a study in view of the extreme rarity of angiosarcomas of the liver and the problems of a correct diagnosis of this disease would most likely not have been possible in a methodical and probelm-free manner.

Therefore, the method of the historically prospective cohort study was selected. In this epidemiological stype of study, a group of people (cohort) which can be clearly defined by a common characteristic (in this case: exposure to VCM) is followed in their fate from a point in time in the past to a defined final point. The disease resp. mortality risk of these cohorts is then compared to the corresponding risk of a comparison group (most times the entire population). Since usable data sources for the evaluation of the disease risk of the population in West Germany are not yet available, the investigation was limited to a mortality study.

Within the framework of our investigation, three cohorts of workers with their mortality risks were analyzed.

1. All workers who had been or still are involved in the production of VCM resp. PVC in the Federal Republic of Germany (7,021 workers of German and Austrian nationality).

2. A cohort of 4,910 workers of German and Austrian nationality from the same factories of the chemical industry without contact with VCM.

3. A cohort of 3,943 workers of German and Austrian nationality from two PVC processing plants.

2. Material and Methods

1. Vinyl chloride mortality study

Data of all workers who were involved or still are in the 11 vinyl chloride (VCM) resp. polyvinyl chloride (PVC) producing plants in the Federal Republic of Germany up to December 31, 1984 were collected. The following data were secured for each individual worker:

- three initial letters of first and last name,
- date of birth,
- nationality,
- first date of employment,
- date of first exposure to VCM,
- date of last exposure to VCM,
- last date of employment,
- last date the worker with certainty was still alive,
- date of death for deceased workers.

Weighting factors were separately calculated for six age classes and three observation periods (Table 1.1 to Table 1.3). A similar method was used by Tabershaw. It is presupposed in this method that the unexplainable causes of death - if been explainable - contained the specific causes of death in the same distribution as the explained causes of death, in other words, if 30 % myocardinal infarctions are found among the explained causes of death, the percentage of myocardinal infarctions among the unexplained causes of death also would have been 30 %.

Exceeding the 95 % resp. 99 % confidence interval was examined for the calculated SMR (Bailar, 1964).

2. Mortality study of workers in the chemical industry who were not exposed to VC

From seven plants of the chemical industry, the data of 4,910 male workers were acquired, who in their total structure could be compared with the group exposed to VC but who had not been exposed to VC nor PVC processing. The acquisition methods for this comparison group were identical except for the data on first and last exposure omitted in this case.

3. Mortality study of workers of PVC processing plants

Analogous to the method illustrated under 1, the data of workers from two plants were acquired and processed who had been involved in PVC processing, therefore, in general exposed in any case to a very slight VC concentration.

This study in the analysis only included the data of German and Autrian workers.

3. Results

3.1 Basic data

Cohort 1 of the workers of the chemical industry exposed to VCM (7,021) could have included almost all workers who were exposed to VCM at one time or another. A comparable complete inclusion for the other cohorts of the study (cohorts 2 - workers not exposed to VCM, cohorts 3 - workers from PVC processing) could not be attained.

A comparison of the basic data of these cohorts shows that workers exposed to VCM with an average observation period of 10.5 years could be observed for this study for a considerably shorter period than the cohorts of the unexposed workers (15.5 years observation period) or the cohorts of the workers from PVC processing with 13.2 years (calculated from Table 2).

Table 1. Weighting factors for specific causes of death for the calculation of SMR

Tab. 1 Gewichtungsfaktoren für spezifische Todesursachen zur Berechnung der SMR

Zeitraum time period	Altersgruppe age group 0-24	25-34	35-44	45-54	55-64	65 +	Summe total
— 1959 total deaths							
Todesfälle insgesamt	1	7	6	12	13	2	41
Todesursache unbekannt cause unknown	0	0	2	2	2	0	6
Gewichtungsfaktor weighting factor	1	1	1,5	1,2	1,1818	1	
1960—1969							
Todesfälle insgesamt	5	18	27	39	52	38	179
Todesursache unbekannt	0	1	2	4	2	2	11
Gewichtungsfaktor	1	1,0588	1,08	1,1143	1,04	1,0556	
1970—1974							
Todesfälle insgesamt	4	20	32	39	40	59	194
Todesursache unbekannt	1	3	3	0	3	3	13
Gewichtungsfaktor	1,3333	1,1765	1,1034	1	1,0811	1,0536	

Tab. 1.1 VCM-exponierte Arbeiter (Kohorte I) workers exposed to VCM (cohort 1)

Zeitraum	Altersgruppe 0-24	25-34	35-44	45-54	55-64	65 +	Summe
— 1959							
Todesfälle insgesamt	3	2	13	17	17	3	55
Todesursache unbekannt	—	1	5	5	2	3	18
Gewichtungsfaktor	1	2	1,625	1,4167	1,5455	1,5	
1960—1969							
Todesfälle insgesamt	3	13	21	35	96	44	212
Todesursache unbekannt	—	1	1	7	8	3	20
Gewichtungsfaktor	1	1,0833	1,05	1,25	1,0909	1,0732	
1970—1974							
Todesfälle insgesamt	3	6	11	21	37	72	150
Todesursache unbekannt	—	—	3	4	—	2	9
Gewichtungsfaktor	1	1	1,375	1,2353	1	1,0286	

Tab. 1.2 Nicht VCM-exponierte Arbeiter (Kohorte II) workers not exposed to VCM (cohort 2)

Zeitraum	Altersgruppe 0-24	25-34	35-44	45-54	55-64	65 +	Summe
— 1959							
Todesfälle insgesamt	1	4	4	11	11	4	35
Todesursache unbekannt	—	4	2	3	3	2	14
Gewichtungsfaktor	1	—	2	1,375	1,375	2	
1960—1969							
Todesfälle insgesamt	4	17	22	29	51	56	179
Todesursache unbekannt	1	2	4	5	4	5	21
Gewichtungsfaktor	1,3333	1,1333	1,2222	1,2083	1,0851	1,098	
1970—1974							
Todesfälle insgesamt	3	7	18	21	44	53	146
Todesursache unbekannt	1	1	5	2	2	1	12
Gewichtungsfaktor	1,5	1,1667	1,3846	1,1053	1,0476	1,0192	

Tab. 1.3 Arbeiter der PVC-Weiterverarbeitung (Kohorte III) PVC processing workers (cohort 3)

without exposure

	Kohorte I VCM-/PVC-Herstellung product.	Kohorte II Ohne VCM-/PVC-Exposition	Kohorte III PVC-Weiterverarbeitung processing
GERMAN/AUSTRIAN Population (Deutsche und Österreicher)	7.021	4.910	4.007
Follow-up bis 31. 12. 1974	93,2	89,8	92,1%
Mannjahre MEN YEARS	73.734	76.029	52.896
Bis 31. 12. 1974 verstorben DECEASED	414	417	360
Todesursache nicht zu ermitteln CAUSE OF DEATH NOT KNOWN	7,2	11,3	13,1
Ausländer FOREIGNERS	882	711	1.454
davon verstorben	6	6	10

Tab. 2 Grunddaten für die Kohorten I, II und III
Basic data for cohorts 1,2,3

A comprehensive comparison of cohorts 1 and 2 (Table 3-5) shows in addition that the workers of cohort 2 earlier in time became a member of the investigated cohorts as a result of their entry into the company: 32.4 % of men years are found in the period to 1959 compared to 16.1 % for the workers of cohort 1. The workers of cohort 2 were, moreover, slightly older than the workers of cohort 1: calculated to men years, a percentage of 34.2 % in cohort 2 is found in age classes above 44 years compared to 28.2 % in cohort 1.

age group

time Zeitraum / Altersgruppen	— 24	25—34	35—44	45—54	55—64	65 +	total Summe
—1959	2142,11	4044,31	3007,49	1925,36	675,68	94,75	11889,70
1960—1969	4107,57	11841,72	9144,15	5479,80	3287,0	676,93	34537,17
1970—1974	2016,32	7716,39	8933,28	4891,50	2670,34	1079,15	27306,98
Summe total	8266,0	23602,42	21084,92	12296,66	6633,02	1850,83	73733,85

Tab. 4 Mannjahre von VCM-exponierten Arbeitern men years of workers exposed to VCM (cohort1) *(Kohorte I)*

Altersgruppen / Zeitraum	— 24	25—34	35—44	45—54	55—64	65 +	Summe
—1959	3954,28	6850,10	7039,16	5285,86	1390,91	137,09	24657,40
1960—1969	3465,97	9264,61	8265,61	5942,43	4248,09	1074,0	32260,71
1970—1974	1418,73	4270,88	5557,39	3862,21	2560,80	1441,02	19111,03
Summe	8838,98	20385,59	20862,16	15090,50	8199,80	2652,11	76029,14

Tab. 5 Mannjahre von nicht VCM-exponierten Arbeitern men years of unexposed workers (cohort2) *(Kohorte II)*

exposed to VCM resp. PVC

KOHORTE I 1. Exposition gegen VCM bzw. PVC in 19..

year of birth

Geburtsjahr	—44	45-49	50-54	55-59	60-64	65-69	70-74
—1884	2	1	—	—	—	—	—
1885—1889	1	4	1	—	—	—	—
1890—1894	3	5	5	1	—	—	—
1895—1899	6	22	16	8	7	—	—
1900—1904	11	23	35	36	20	4	—
1905—1909	9	24	63	64	54	29	1
1910—1914	18	26	78	88	77	42	13
1915—1919	4	22	95	91	52	42	24
1920—1924	8	41	122	135	97	81	70
1925—1929	5	25	147	198	142	154	130
1930—1934	—	17	107	264	230	252	177
1935—1939	—	—	42	272	360	269	282
1940—1944	—	—	8	132	297	363	302
1945—1949	—	—	—	1	94	245	294
1950—1954	—	—	—	—	1	84	368
1955—1959	—	—	—	—	—	—	78

entry into company

KOHORTE II Eintritt in den Betrieb in 19..

Geburtsjahr	—44	45-49	50-54	55-59	60-64	65-69	70-74
—1884	—	2	—	—	—	—	—
1885—1889	7	2	—	—	—	—	—
1890—1894	14	13	2	—	—	—	—
1895—1899	65	19	3	1	—	—	—
1900—1904	124	61	19	16	1	—	—
1905—1909	112	66	45	44	7	2	—
1910—1914	112	77	71	91	21	2	1
1915—1919	30	58	76	62	28	9	2
1920—1924	50	89	118	127	59	31	16
1925—1929	53	89	125	156	70	51	33
1930—1934	5	45	127	222	126	67	51
1935—1939	—	—	64	245	193	136	81
1940—1944	—	—	4	147	157	141	94
1945—1949	—	—	—	5	66	142	113
1950—1954	—	—	—	—	3	78	167
1955—1959	—	—	—	—	—	5	72

KOHORTE III 1. Exposition gegen PVC in 19..

exposed to PVC

Geburtsjahr	—44	45-49	50-54	55-59	60-64	65-69	70-74
—1884	1	1	—	—	—	—	—
1885—1889	2	11	1	—	—	—	—
1890—1894	3	19	13	2	—	—	—
1895—1899	—	17	28	4	9	—	—
1900—1904	2	47	42	16	23	1	—
1905—1909	3	30	39	55	48	3	—
1910—1914	3	36	51	111	62	11	11
1915—1919	6	30	34	92	54	17	23
1920—1924	10	47	47	148	72	23	19
1925—1929	7	25	75	215	105	41	26
1930—1934	—	16	75	254	168	66	40
1935—1939	—	—	36	289	253	90	49
1940—1944	—	—	2	54	222	124	77
1945—1949	—	—	—	41	25	99	77
1950—1954	—	—	—	—	1	17	135
1955—1959	—	—	—	—	—	—	16

Table 3. Year of birth and first exposure resp entry into the company.

These differences in structure must be properly considered in comparing the SMR.

The follow-up for all three cohorts shows values leading to the supposition that the SMR would not relevantly change as a result of a more comprehensive explanation of the fate of workers whose addresses could no longer be determined.

The percentage of no longer explainable causes of death is only desirably low in cohort 1. In view of the 5 year record keeping term for death certificates we will have to accept values of about 10 % for unexplainable causes of death in the Federal Republic also for future investigations.

3.2 Standardized mortality rates

A. Total mortality

The total mortality of cohorts 1 and 3 with 95 each is found very close to the total mortality of the total population (Table 6). Cohort 2, on the other hand, with an SMR of 78 has a clearly lower value compared to the total population.

When considering the total mortality in the individual age classes (Table 9, 11, 15) a lower SMR is found in cohort 1 only for the workers under 25 years of age and for the 55-64 year old workers; only the latter is statistically significantly reduced. Cohort 3 in all age classes has a total mortality which equals the total population.

The SMR of cohort 2 for the 25-54 year old workers, on the other hand, is significantly lower.

When analyzing the SMR for the total mortality of the three cohorts according to the observation period, the lowest value is obtained for all in the period up to 1959. This lower value is, however, only statistically significant for cohort 2 and cohort 3. Cohort 2, in addition, shows a lower SMR in the period from 1970 to 1974 (Table 7, 10, 13).

B. Specific SMR

In the following, only those specific causes of death with their SMR will be discussed which were found beyond the 95 % confidence range with the SMR definition under the assumption of a Poisson's distribution.

As mentioned above, instigation for the study was the observation of individual cases of hemangiosarcomas of the liver in workers exposed to VCM. The ICD code 155 includes all malignant tumors having their primary seat in the liver. As a result of the extreme rarity of this disease and its relative unfamiliarity in earlier years, the exact diagnosis of hemangiosarcoma in long ago deaths

could be seldom made and as seldom be filled in on the death certificate. In this respect, statements on a higher SMR can only be made by also including other malignant liver tumors.

In the cohort of the workers exposed to VCM, the SMR for malignant tumors of the liver with 1523 is extremely high (Table 6). This elevation is found in all age classes of the cohort in which malignoma of this type were observed. The highest values occur in the age classes 35-44 year old workers (Table 9). A very clear SMR elevation is found over the individual observation periods (Table 7) and an equally clear increase with increasing exposure duration to VCM (Table 8).

A comparatively lower SMR elevation for liver malignoma is found in cohort 2 (SMR = 401). A more detailed classification of the few observed cases only indicates an increase between 1960 and 1969 (Table 10).

The SMR elevation for malignant tumors of the digestive organs (ICD 150-159) in cohort 1 could possibly be traced to the liver malignancies occurring in excess in this cohort (Table 6). When subtracting the number of liver malignoma from the total malignoma of this range, an SMR is obtained which is not any longer statistically significantly increased with 109.

Only in a classification according to observation period and only for the time to 1959, an increased SMR for malignoma of the stomach (ICD 151) with 446 is found (Table 7).

In cohort 1, the SMR for tumors of the lymphatic and hamatopoetic tissue (ICD 200-209) with 214 is clearly higher. It is suggested that an increase occurs with increased exposure time (Table 8), although none of the values is statistically significantly higher because of the small number of observations in this type of classification. A classification according to observation period seems to indicate an increased frequency between 1960 and 1969 (Table 7).

A higher SMR is found in cohort 3 with one form of malignoma: malignant brain tumors compared to the total population are higher by 435 % (Table 6). A preference in the 45-54 year old worker (Table 15)and an increased frequency beteen 1960 and 1969 are found (Table 13).

All three cohorts have an SMR increase in common for ischemic heart diseases (ICD 410-414) (Table 6). A sub-division according to observation period results in a non-uniform situation: in cohort 1 an increase is only found between 1960 and 1969, in cohort 3 as of 1960 and in the cohort of workers not exposed to VCM only since 1970 (Tables 7, 10, 13).

A sub-classification according to age classes indicates a preference in higher age classes (Table 11, 15).

Only in the cohort of workers exposed to VCM, an increase in accidents of all types (ICD 800-949) is recorded. In this case, an increasing tendency is demonstrated with observation period (Table 7).

4. Discussion

The results of different published mortality studies show such a varied situation that it is difficult to recognize a common pattern, (3, 4, 6, 7, 11).

Whereas Duck et al (1975) USA for a population of persons indicate a total mortality of 96 with lower SMR at increasing exposure duration (under ten years of exposure: 112, ten to fourteen years of exposure: 107, fifteen and more years of exposure: 61) Duck and Carter (1976) correct the result for the worker group with the longest exposure to an SMR of 104.

In contrast, Fox and Collier (1977) find a total mortality of 75.4 for a population three times as large and a considerable fluctuation between the various investigated Brittish plants (SMR 12.3 to 88.8). Their analysis shows also a continuously lower SMR tendency since the first observation period: whereas it was still 87.4 for 1940-1944, it dropped to 53.1 for the period of 1970-1974. In a classification according to exposure duration, these authors, however, find a clear increase: men, still alive 15 years after the study began, show an SMR (100.6) for an exposure duration of up to five years which does not differ from the total population; it already reaches a value of 113.3 for an exposure duration of ten to fourteen years.

The two US studies (4, 12), to be sure, have the largest study population available (N = 9,677) and the largest number of person years (120,203 in (4)) but their results are sometimes contradictory: whereas the first analysis (Tabershaw and Gaffey, 1974) in a follow-up of 85 % still has an SMR of 75, the second analysis with an improved follow-up of 95 % shows an SMR of 89 (4). With increasing exposure duration, to be sure, a slight but inconsistent SMR increase is found in the second analysis. The SMR in the group of men exposed for the shortest time (1-4 years) and with the least exposure intensity indicating a "healthy worker effect" is nevertheless equally significantly reduced (SMR 82) as the SMR of the highly exposed men (5-9 years, SMR 48) resp. the SMR of a group of men with average exposure intensity who were exposed for a long time (20-24 years) (SMR 66). These inconsistent tendencies do not allow a meaningful interpretation at this time.

A comparable "healthy worker effect" is, in contrast, not found in the workers of BASF, Ludwigshafen studied by Frentzel-Beyme et al (1978). A lower SMR (70) was only found for the group exposed for the shortest time (up to 4 years) whose exposure started after 1960 whereas all other groups had higher values. This study

group could also observe an effect similar to the effect observed by Fox and Collier (1978): an earlier exposure start results in a higher SMR (before 1960, SMR = 140; after 1960, SMR = 102). Also in this population, moreover, the longer the minimum observation time of the population, the higher the SMR, the SMR for a minimum observation time of 5 years is 99, for a minimum observation time of 10 years, on the other hand, it is 117.4.

When in a population consisting of industrial workers who must provide a selection with respect to health, a difference in the total mortality compared to the total population is not found, it must be assumed that the SMR is relatively elevated. This assumption is confirmed by the comparison of the SMR's of the three investigated cohorts (Table 6). Accordingly, only cohort 2 (not exposed to VCM) shows the "healthy worker effect. It is lacking in cohorts 1 and 3.

The considerable differences with respect to total mortality and also to specific mortality found in comparing the US study and the study by Fox and Collier with the present study must be discussed under the topics of different detecting methods in determining the population of exposed workers and of different exposure intensity. Whereas Fox and Collier included all workers who "could" have been exposed to VCM in the population of their study, the population of the German study was limited to those workers who were clearly and continuously exposed. This results in a comparatively more intensely exposed German population.

Further references to a comparatively lower exposure result from a comparison of the PVC production numbers for 1974:

	workers	production in tons	consumption in tons	capacity in tons
Great Britain	7,717	381,000	410.000	575,000
West Germany	7,021	1,070,000	943,000	1,355,000

Table 12.

When assuming an approximately equal productivity in the PVC chemical industry per worker, the British population as a result of fewer or hardly exposed workers would have to be "diluted" to a reduced risk. It does not seem probable, however, that the British productivity is only one third of the German productivity (Great Britain: 49,400 tons per 1000 workers; Germany 152,400 tons per 1000 workers).

When assuming, on the other hand, a reduced productivity and a comparable PVC production technology, a resulting VC burden on the population would be divided over a comparatively larger population resulting again in a lower exposure per population unit. These effects unfortunately cannot be estimated since Fox and Collier only give total numbers of their population but not person years.

The most important finding of the present study undoubtedly concerns the much higher SMR for malignoma of the liver. Fox and Collier find a significantly higher SMR only in the most burdened sub-group of their population. The American studies, on the other hand, do not mention an increased mortality risk for malignoma of the liver although, meanwhile, 85 hemangiosarcomas of the liver in personsexposed to PVC became known by the end of 1980 with the largest number in the USA.

These differences can be traced to various factors:

1. Since there is no indication that more intensively or longer exposed persons in Great Britain were investigated less exactly than in the Federal Republic, a more intense total exposure in the Federal Republic could be concluded.

2. The lacking increase in the USA again could have three reasons:

- The fixed date of detecting the population in the US was December 31, 1972. It can be assumed that with the relatively long latency period a number of persons were not included until later years.

- It is also possible that the SMR for primary liver tumors (ICD 155)has increased but is not expressed in the results. In the SMR tables, all causes of death traced to diseases of the gastrointestinal tract and the peritoneum (ICD-7 150-159) are combined.

- It can be suspected that the ten cases observed in this study falling under the category ICD 155 would lead to a significantly higher SMR also in the American study with a separate calculation of the SMR for the ICD position 155.

The SMR increase observed in the present study for tumors of the lymphatic and hamatopoetic system (ICD 200-209) is not found in any other study in this manner. The American study, however, includes a suggested increase for leukemia/aleukemia (ICD 204) as well as for lymphoma (ICD 200-203, 205).

The SMR increase observed in our study for ischemic heart diseases (ICD 410-414) (see Table 6) would under the circumstances have been incorrectly attributed to exposure to VC if a comparable increase would not have been found also in the cohort of the unexposed workers and in the cohort of workers of PVC processing. This demonstrates the great advantage of the analysis of a comparison group consisting of industry workers. The result of the ischemic heart diseases at the same time pointed out an imminent methodical defect of this study formulation: the essential risk factors for ischemic heart diseases but also for various carcinoma (smoking,

dietary habits, etc.) cannot be detected and escape the analysis, therefore. The present findings impressively support the determination already made in 1977 by the National Institute for Occupational Safety and Health (NIOSH) (Key et al, 1977) that vinyl chloride must be viewed as carcinogenic for humans and is causally responsible for angiosarcomas of the liver.

It must be expected that as a result of the long latency period assumed for the development of hemangiosarcomas of the liver but also for other tumors, a further collective follow-up investigation of exposed workers will provide definite statements on the carcinogenicity of VCM.

5. Summary

1. In a historic prospective mortality study the fate of all of the male employees of the chemical industry in West Germany engaged in the production of vinyl chloride monomer and polyvinyl chloride as well (11 factories) is studied. Employees of German and Austrian nationality only have been included in the analysis (N = 7,021). For various reasons, the data of 882 foreigners (6 of whom deceased) were excluded.

2. The fate of 4,007 employees of the PVC processing industry (2 factories) and of 4,910 employees of the chemical industry without exposure to VCM/PVC has been analyzed in identical manner.

3. Follow-up rate came to about 90 % at the endpoint of the study (12-31-1974). Resulting person years came to 73,734 (VCM/PVC exposed), 52,896 (PVC processing), and 76,029 (without exposure to VCM/PVC) respectively.

4. Using the male population of West Germany within the respective calendar years as reference, the standardized mortality rate (SMR) of employees exposed to VCM/PVC or engaged in PVC processing failed to demonstrate any "healthy worker effect".

5. SMR for malignant tumors of the liver (ICD-8 155) shows an extraordinary dose-dependent elevation for VCM/PVC workers. A relatively small increase for ICD-8 155 is also to be found in nonexposed workers.

6. SMR for malignancies of lymphatic and hematopoetic tissues (ICD-8 200-209) is considerably increased in VCM/PVC exposed workers.

7. SMR for malignancies of the brain (ICD-8 191) is elevated in employees of PVC processing factories.

8. All of the three cohorts analyzed demonstrate an elevated SMR for ischemic heart diseases (ICD-8 410-414).

9. Considering the long latency periods for malignant tumors and the increasing number of observations of hemangiosarcomas of the liver (West Germany 1974: 4 cases, 1980: 18 cases) as well, further follow-up studies of the population exposed to VCM/PVC seems to be highly advisable.

Table 6. SMR of cohorts 1, 2, 3 of the study

		exposed to Kohorte I VCM-/PVC-Exposition		not exposed Kohorte II Keine VCM-Exposition		PVC processi Kohorte III PVC-Weiterverarbeitung	
ICD	Diagnose observation va. / expection value	Beob.-wert Erw.-wert	SMR	Beob.-wert Erw.-wert	SMR	Beob.-wert Erw.-wert	SMR
	Gesamtmortalität total mortality	414 434,7	95	417 533	78**	360 379,6	95
140-209	Maligne Tumoren der Organe und systematische Malignome malignant tumors and systematic malignoma	94 90,6	112	83 113,7	83	62 81,9	85
140-199	Maligne Tumoren der Organe malignant tumors of the organs	79 82,9	103	77 104,8	83	60 75,6	89
200-209	Tumoren des lymphatischen und haematopoetischen Gewebes tumors of the lymphatic and hematop. tissue	15 7,7	214**	6 8,9	77	2 6,3	34
150-159	Maligne Tumoren der Verdauungsorgane of the digestive organs	45 32,7	149*	27 41,8	71	15 30,3	56
151	Maligne Tumoren des Magens of the stomach	18 14,4	138	10 18,6	62	7 13,5	57
153	Maligne Tumoren des Dickdarms of the colon	6 5,8	109	3 7,3	42	1 5,3	26
155	Maligne Tumoren der Leber of the liver	12 0,9	1523**	4 1,1	401*	3 0,8	434
160-163	Maligne Tumoren des respiratorischen Systems of the respiratory system	24 26,6	96	30 34	100	25 24,4	113
162	Maligne Tumoren der Trachea, Bronchien und Lunge of the trachea, bronchia lungs	22 24,6	95	30 31,5	108	24 22,6	116
188	Maligne Tumoren der Harnblase of the bladder	1 2,9	36	2 3,7	63	2 2,8	77
191	Maligne Tumoren des Gehirns of the brain	2 1,3	162	2 1,6	183	5 1,1	535**
410-414	Ischaemische Herzkrankheiten ischemic heart disease	91 76,5	127*	115 96,7	131**	96 69,4	158**
410	Akuter Herzmuskelinfarkt acute heart muscle infarct	66 61,8	114	83 77,1	120	69 55	143**
430-438	Cerebrovaskuläre Krankheiten cerebrovascular diseases	29 29,4	104	25 39,2	70	23 29,7	82
490-493	Bronchitis, Emphysem und Asthma bronchitis emphysema asthma	6 14,4	44	10 19,2	59	4 14,2	30
571	Leberzirrhose cirrhosis of the liver	14 18,4	82	17 21,3	92	14 15,4	105
800-949	Unfälle accidents	61 49	137*	44 51,3	99	32 35,5	110
950-959	Suizid und Selbstbeschädigung suicide, self destruction	24 25,5	101	16 27,3	70	15 19	92
011	Lungentuberkulose lung tuberculosis	4 5,5	75	4 6,9	65	0 4,8	—

*) Überschreitung des 95%-Vertrauensbereichs exceeding the 95 % confidence range
**) Überschreitung des 99%-Vertrauensbereichs exceeding the 99 % confidence range
(J. C. BAILAR: Significance Factors for the Ratio of a Poisson Variable to its Expectation. Biometrics 20: 639-643, 1964)

Tab. 6: SMR der Kohorten I, II und III der Studie

Table 7. SMR acc. observation period for VCM exposed workers (cohort 1)
observation period Beobachtungszeitraum

ICD	Diagnose	— 1959 Beob.-wert Erw.-wert	SMR	1960-69 Beob.-wert Erw.-wert	SMR	1970-74 Beob.-wert Erw.-wert	SMR
	observ. value / expect. value						
	Gesamtmortalität total mortality	41 52,5	78	179 194,7	92	194 187,5	103
	of the organs and syst. malign						
140-209	Maligne Tumoren der Organe und systematische Malignome	13 9,8	159	38 40,5	101	43 40,3	113
	of the organs						
140-199	Maligne Tumoren der Organe	12 8,8	160	29 37	84	38 37,2	108
	of the lymph. and hematopoet. tissue						
200-209	Tumoren des lymphatischen und haematopoetischen Gewebes	1 1	147	9 3,5	275**	5 3,1	168
	of the digestive organs						
150-159	Maligne Tumoren der Verdauungsorgane	8 3,5	270*	13 14,9	94	24 14,4	177*
	of the stomach						
151	Maligne Tumoren des Magens	6 1,6	446**	3 6,8	48	9 6	158
	of the colon						
153	Maligne Tumoren des Dickdarms	1 0,6	196	1 2,5	43	4 2,6	153
	of the liver						
155	Maligne Tumoren der Leber	1 0,09	1282	3 0,4	824*	8 0,4	2264**
	of the respiratory system						
160-163	Maligne Tumoren des respiratorischen Systems	1 2,7	44	14 11,8	127	9 12,2	78
	of the trachea, bronchia lungs						
162	Maligne Tumoren der Trachea, Bronchien und Lunge	1 2,4	48	12 10,9	117	9 11,3	84
	of the bladder						
188	Maligne Tumoren der Harnblase	0 0,3	—	1 1,2	88	0 1,4	—
	of the brain						
191	Maligne Tumoren des Gehirns	1 0,2	557	0 0,7	—	1 0,4	223
	ischemic heart disease						
410-414	Ischaemische Herzkrankheiten	7 7,9	103	43 33,2	138*	41 35,4	122
	acute heart muscle infarct						
410	Akuter Herzmuskelinfarkt	7 6,5	125	32 26,8	128	27 28,6	100
	cerebrovascular						
430-438	Cerebrovaskuläre Krankheiten	1 2,7	44	13 13,1	104	15 13,6	116
490-493	Bronchitis, Emphysem und Asthma	1 1,4	86	1 6,7	15	4 6,3	65
	cirrhosis of the liver						
571	Leberzirrhose	1 1,9	62	7 7,4	101	6 9	71
	accidents						
800-949	Unfälle	7 7,9	103	27 22,9	125	27 18,3	167*
	suicide and selfdestruction						
950-959	Suizid und Selbstbeschädigung	0 4	—	9 12	79	15 9,6	170
	tuberculosis						
011	Lungentuberkulose	2 0,8	245	2 3	70	0 1,7	—

as in Table 6

*) *Überschreitung des 95%-Vertrauensbereichs*
**) Überschreitung des 99%-Vertrauensbereichs
(J. C. BAILAR: Significance Factors for the Ratio of a Poisson Variable to its Expectation. Biometrics 20: 639-643, 1964)

Tab. 7: SMR nach Beobachtungszeitraum bei VCM-exponierten Arbeitern (Kohorte I)

Tab. 8. SMR acc. exposure duration for VCM exposed workers (cohort 1)

		exposure duration (months) Expositionsdauer (Monate) — 12		13 - 60		61 - 120		121 +	
ICD	Diagnose observ. v. expect. v.	Beob.-wert Erw.-wert	SMR	Beob.-wert Erw.-wert	SMR	Beob.-wert Erw.-wert	SMR	Beob.-wert Erw.-wert	SMR
	total mortality Gesamtmortalität	53 57,3	93	138 135,9	102	93 106,7	87	130 134,7	96
140-209	of the organs and syst. malign. Maligne Tumoren der Organe und systematische Malignome	59 66,5	90	158 159,8	100	125 127,6	92	161 163,6	99
140-199	of the organs Maligne Tumoren der Organe	6 9,2	74	20 23,9	88	22 20,9	116	31 28,9	115
200-209	of the lymph. hem. Tumoren des lymphatischen und haematopoetischen Gewebes	1 1,1	92	4 2,5	186	5 1,9	287	5 2,1	249
150-159	of the digenstive org. Maligne Tumoren der Verdauungsorgane	3 3,5	101	12 9,4	135	13 8,3	173	17 11,5	158
151	of the stomach Maligne Tumoren des Magens	2 1,5	168	7 4,1	175	7 3,7	215	2 5	41
153	of the colon Maligne Tumoren des Dickdarms	1 0,6	154	1 1,7	71	3 1,5	215	1 2	50
155	of the liver Maligne Tumoren der Leber	0 0,09	—	2 0,2	874*	3 0,2	1525**	7 0,3	2528**
160-163	of the resp. syst. Maligne Tumoren des respiratorischen Systems	1 2,8	38	6 7,3	85	6 6,8	95	11 9,8	121
162	Maligne Tumoren der Trachea, Bronchien und Lunge	1 2,5	41	6 6,8	93	6 6,2	103	9 8,1	106
188	of the bladder Maligne Tumoren der Harnblase	0 0,3	—	0 0,8	—	1 0,7	144	0 101	—
191	of the brain Maligne Tumoren des Gehirns	0 0,2	—	0 0,4	—	1 0,3	350	1 0,4	278
410-414	ischemic heart dis. Ischaemische Herzkrankheiten	9 8,2	117	25 21,6	123	19 19,4	106	38 27,2	148*
410	heart mus. infarct Akuter Herzmuskelinfarkt	6 6,8	95	19 17,5	115	14 15,6	98	27 21,9	131
430-438	Cerebrovaskuläre Krankheiten	0 2,9	—	10 8,6	123	7 7,5	99	12 10,5	122
490-493	Bronchitis, Emphysem und Asthma	0 1,4	—	0 4,1	—	3 3,7	89	3 5,2	58
571	cirr. of the liver Leberzirrhose	1 2,3	46	2 5,5	40	6 4,6	140	5 6	90
800-949	accidents Unfälle	11 10,3	117	27 19,2	158*	12 10,7	121	11 8,9	135
950-959	suicide and selfdes. Suizid und Selbstbeschädigung	5 4,7	114	12 9,5	135	4 5,9	73	3 5,4	60
011	Lungentuberkulose	0 0,7	—	2 1,7	119	1 1,4	71	1 1,6	63

*) Überschreitung des 95%-Vertrauensbereichs
**) Überschreitung des 99%-Vertrauensbereichs
(J. C. BAILAR: Significance Factors for the Ratio of a Poisson Variable to its Expectation. Biometrics 20: 639-643, 1964)

Tab. 9. SMR acc. to age classes

ICD	Diagnose	Altersklassen age classes — 24 Beobachtungswert / Erwartungswert	SMR	25 — 34 Beobachtungswert / Erwartungswert	SMR	35 — 44 Beobachtungswert / Erwartungswert	SMR	45 — 54 Beobachtungswert / Erwartungswert	SMR	55 — 64 Beobachtungswert / Erwartungswert	SMR	65 + Beobachtungswert / Erwartungswert	SMR
	total mortality Gesamtmortalität	10 14,6	68	45 40,5	111	65 62,5	104	90 89	101	105 131,9	80	90 96,2	103
140 - 209	Maligna Tumoren der Organe und systematische Malignome	0 0	—	6 4,0	156	17 9,4	208	23 19,6	126	24 33,5	81	23 23,3	105
140 - 199	Maligne Tumoren	0 0,6	—	4 2,9	141	13 7,8	188*	19 18	114	22 31,5	76	21 22,2	100
200 - 209	*Tumoren des lymphatischen und* haematopoetischen Gewebes	0 0,4	—	2 1,1	194	4 1,6	303	4 1,6	264	3 2	162	2 1,1	197
150 - 159	Maligne Tumoren der Verdauungsorgane und des Peritoneums	0 0,08	—	3 0,8	397	10 3,1	365**	10 7,4	145	10 12,4	89	12 9	140
151	Maligne Tumoren des Magens	0 0,003	—	2 0,3	740	2 1,3	208	5 3,3	165	5 5,5	101	4 4,1	104
153	Maligne Tumoren des Dickdarms	0 0,03	—	0 0,2	—	1 0,7	163	4 1,2	337	0 2	—	1 1,6	65
155	*Maligne Tumoren der Leber*	0 0,002	—	0 0,02	—	6 0,096	6865**	0 0,2	—	3 0,4	934**	3 0,2	1664
160 - 163	Maligne Tumoren des respiratorischen Systems	0 0,05	—	0 0,3	—	1 1,7	64	6 5,7	113	10 11,6	92	7 7,4	100
162	Maligne Tumoren der Trachea, Bronchien und Lunge	0 0,05	—	0 0,2	—	1 1,5	73	4 5,2	81	10 10,8	99	7 6,8	108
188	Maligne Tumoren der Harnblase	0 0,004	—	0 0,02	—	0 0,3	—	0 0,5	—	0 1,1	—	1 1	104
191	Maligne *Tumoren des Gehirns*	0 0,03	—	0 0,2	—	0 0,4	—	1 0,4	254	1 0,3	362	0 0,06	—
410 - 414	Ischaemische Herzkrankheiten	0 0,07	—	2 1,2	191	7 7,7	98	26 18,6	150	33 29,3	121	22 19,6	123
410	Akuter Herzmuskelinfarkt	0 0,07	—	2 1,1	210	5 6,9	78	20 18	134	27 23,8	122	12 14	90
430 - 438	Cerebrovasculäre Krankheiten	0 0,1	—	0 0,7	—	1 1,8	60	3 4,1	75	12 10	127	13 12,7	108
490 - 493	Bronchitis, Emphysem und Asthma	0 0,05	—	0 0,2	—	0 0,7	—	2 2	100	2 5,7	39	2 5,7	37
571	Leberzirrhose	0 0,05	—	0 0,9	—	2 3,6	61	4 5,2	85	3 5,9	55	5 2,7	194
800 - 949	Unfälle	7 7,6	100	22 14,4	171*	11 11,7	106	13 7,6	187*	3 5,5	58	5 2,2	240
950 - 959	Suizid und Selbstbeschädigung	1 2	49	4 6,5	69	9 7,3	135	4 5,4	77	4 3,4	124	2 0,9	225
011	Lungentuberkulose	0 0,02	—	1 0,4	286	0 1,1	—	0 1,5	—	1 1,7	62	0,8 0,8	262

obs. val.
expect.

*Überschreitung des 95%-Vertrauensbereichs **Überschreitung des 99%-Vertrauensbereich
(J. C. Bailar: Significance Factors for the Ratio of a Poisson Variable to its Expectation. Biometrics 20:639-643, 1964)

Tab. 10. SMR for unexposed to VCM-workers acc. observation period

observation period
Beobachtungszeitraum

ICD	Diagnose	— 1959 Beob.-wert Erw.-wert	— 1959 SMR	1960 - 69 Beob.-wert Erw.-wert	1960 - 69 SMR	1970 - 74 Beob.-wert Erw.-wert	1970 - 74 SMR	Total Beob.-wert Erw.-wert	Total SMR
	Gesamtmortalität	55 115,3	48**	212 232,4	91	150 185,4	87**	417 533,0	78**
140-209	Maligne Tumoren der Organe und systematische Malignome	7 21,7	48	49 50,8	108	27 41,6	68	83 113,7	83
140-199	Maligne Tumoren	7 19,1	54	45 46,9	107	25 38,8	67	77 104,8	83
200-209	Tumoren des lymphatischen und haematopoetischen Gewebes	0 2,2	—	4 3,9	116	2 2,8	85	6 8,9	77
150-159	Maligne Tumoren der Verdauungsorgane	1 7,7	20	16 19	93	10 15,2	69	27 41,8	71
151	Maligne Tumoren des Magens	1 3,5	44	6 8,7	77	3 6,4	51	10 18,6	62
153	Maligne Tumoren des Dickdarms	0 1,3	—	1 3,2	34	2 2,8	73	3 7,3	42
155	Maligne Tumoren der Leber	0 0,2	—	3 0,5	680*	1 0,4	266	4 1,1	401**
160-163	Maligne Tumoren des respiratorischen Systems	3 5,8	77	18 15,4	130	9 12,9	74	30 34	100
162	Maligne Tumoren der Trachea, Bronchien und Lunge	3 5,3	84	18 14,2	140	9 12	80	30 31,5	108
188	Maligne Tumoren der Harnblase	0 0,5	—	2 1,6	144	0 1,6	—	2 3,7	63
191	Maligne Tumoren des Gehirns	2 0,5	597	0 0,7	—	0 0,4	—	2 1,6	184
410-414	Ischaemische Herzkrankheiten	6 17,7	51	50 42,1	132	59 36,9	167**	115 96,7	131**
410	Akuter Herzmuskelinfarkt	6 14,7	61	40 33,4	184	37 29	135*	83 77,1	120
430-438	Cerebrovaskuläre Krankheiten	2 5,5	56	12 17,6	73	11 16,1	70	25 39,2	70
490-493	Bronchitis, Emphysem und Asthma	1 2,8	52	5 9,1	61	4 7,3	59	10 19,2	59
571	Leberzirrhose	2 4,4	70	11 8,9	135	4 8	56	17 21,3	92
800-949	Unfälle	9 16,0	79	24 21,8	118	11 13,5	92	44 51,3	99
950-959	Suizid und Selbstbeschädigung	3 8,5	54	8 11,8	76	5 7,1	78	16 27,3	70
011	Lungentuberkulose	0 1,9	—	4 3,5	128	0 1,6	—	4 6,9	65

*) Überschreitung des 95%-Vertrauensbereichs
**) Überschreitung des 99%-Vertrauensbereichs
(J. C. BAILAR: Significance Factors for the Ratio of a Poisson Variable to its Expectation. Biometrics 20: 639-643, 1964)

Tab. 11. SMR acc. to age classes for workers not exposed to VCM (cohort 2) Altersklassen age classes

ICD	Diagnose	observ. val. / expect. val.	— 24		25 — 34		35 — 44		45 — 54		55 — 64		65 +	
		Beobachtungswert / Erwartungswert		SMR		SMR		SMR		SMR		SMR		SMR
	total mortality Gesamtmortalität		9 / 16,2	56	21 / 36,6	57	46 / 63,9	72	72 / 111,0	65	149 / 163,5	91	120 / 141,7	85
140 - 209	Maligne Tumoren der Organe und systematische Malignome		0 / 1,0	—	3 / 3,4	89	5 / 8,5	61	18 / 24,3	97	33 / 41,5	87	24 / 34,1	74
140 - 199	Maligne Tumoren		0 / 0,6	—	3 / 2,5	121	3 / 7,9	42	17 / 22,3	100	32 / 39,1	90	22 / 32,5	71
200 - 209	Tumoren des lymphatischen und haematopoetischen Gewebes		0 / 0,4	—	0 / 0,9	—	2 / 1,6	155	1 / 2	61	1 / 2,4	45	2 / 1,6	134
150 - 159	Maligne Tumoren der Verdauungsorgane und des Peritoneums		0 / 0,09	—	1 / 0,7	149	3 / 3,2	105	3 / 9,2	40	10 / 15,4	73	10 / 13,3	79
151	*Maligne Tumoren des Magens*		0 / 0,03	—	0 / 0,2	—	2 / 1,3	172	2 / 4,2	59	4 / 6,9	69	2 / 6	35
153	Maligne Tumoren des *Dickdarms*		0 / 0,04	—	1 / 0,2	524	0 / 0,7	—	0 / 1,5	—	0 / 2,5	—	2 / 2,4	88
155	Maligne Tumoren der Leber		0 / 0,002	—	0 / 0,02	—	1 / 0,1	1059	0 / 0,2	—	1 / 0,4	249	2 / 0,3	753
160 - 163	Maligne Tumoren des respiratorischen Systems		0 / 0,06	—	0 / 0,2	—	0 / 1,7	—	6 / 7,0	112	16 / 14,3	124	7 / 10,7	78
162	Maligne Tumoren der Trachea, Bronchien und Lunge		0 / 0,05	—	0 / 0,2	—	0 / 1,5	—	6 / 6,5	121	16 / 13,3	133	8 / 9,9	84
188	*Maligne Tumoren der Harnblase*		0 / 0,004	—	0 / 0,02	—	0 / 0,2	—	1 / 0,5	222	0 / 1,4	—	1 / 1,5	72
191	Maligne Tumoren des Gehirns		0 / 0,04	—	0 / 0,2	—	0 / 0,4	—	2 / 0,5	575	0 / 0,4	—	0 / 0,09	—
410 - 414	Ischaemische Herzkrankheiten		0 / 0,07	—	0 / 1,0	—	8 / 8	117	14 / 22,8	78	42 / 36,1	125	51 / 28,7	188**
410	Akuter Herzmuskelinfarkt		0 / 0,07	—	0 / 0,9	—	7 / 7,1	116	13 / 19,5	85	33 / 29,2	122	30 / 20,3	159*
430 - 438	Cerebrovasculäre Krankheiten		0 / 0,1	—	0 / 0,6	—	1 / 1,9	84	0 / 5,2	—	8 / 12,5	72	16 / 19	88
490 - 493	Bronchitis, Emphysem und Asthma		0 / 0,6	—	0 / 0,2	—	0 / 0,7	—	3 / 2,5	155	5 / 7,1	74	2 / 8,5	25
571	Leberzirrhose		0 / 0,06	—	0 / 0,7	—	1 / 3,3	34	2 / 6,2	40	11 / 7,2	179	3 / 3,9	81
800 - 949	Unfälle		9 / 8,1	111	12 / 12,4	105	7 / 11,4	87	6 / 9,4	82	7 / 6,8	119	3 / 3,2	98
950 - 959	Suizid und Selbstbeschädigung		0 / 2,2	—	3 / 5,6	53	4 / 7,2	74	5 / 6,7	96	4 / 4,2	101	0 / 1,3	—
011	Lungentuberkulose		0 / 0,02	—	0 / 0,3	—	0 / 1,2	—	1 / 2	62	1 / 2,2	50	2 / 1,2	183

*Überschreitung des 95%-Vertrauensbereichs **Überschreitung des 99%-Vertrauensbereich
(J. C. Bailar: Significance Factors for the Ratio of a Poisson Variable to its Expectation. Biometrics 20:639-643, 1964)

Tab. 13. SMR acc. observation period for workers from PVC processing (cohort 3)

observation period
Beobachtungszeitraum

ICD	Diagnose (observ. v. / expect. v.)	— 1959 Beob.-wert Erw.-wert	— 1959 SMR	1960-69 Beob.-wert Erw.-wert	1960-69 SMR	1970-74 Beob.-wert Erw.-wert	1970-74 SMR
	Gesamtmortalität	35 / 57,4	61**	179 / 180	99	146 / 142,2	103
140-209	Maligne Tumoren der Organe und systematische Malignome	2 / 11,9	23	36 / 38,5	105	24 / 31,4	83
140-199	Maligne Tumoren der Organe	2 / 10,9		35 / 35,5	111	23 / 29,2	86
200-209	Tumoren des lymphatischen und haematopoetischen Gewebes	0 / 1	—	1 / 3	36	1 / 2,2	47
150-159	Maligne Tumoren der Verdauungsorgane	1 / 4,4	31	8 / 14,5	62	6 / 11,5	58
151	Maligne Tumoren des Magens	0 / 2	—	5 / 6,7	84	2 / 4,8	43
153	Maligne Tumoren des Dickdarms	0 / 0,7	—	0 / 2,5	—	1 / 2,1	66
155	Maligne Tumoren der Leber	0 / 0,1	—	2 / 0,4	622	1 / 0,3	372
160-163	Maligne Tumoren des respiratorischen Systems	1 / 3,5	40	14 / 11,3	138	10 / 9,2	109
162	Maligne Tumoren der Trachea, Bronchien und Lunge	1 / 3,2	43	13 / 10,5	138	10 / 8,9	118
188	Maligne Tumoren der Harnblase	0 / 0,3	—	1 / 1,2	89	1 / 1,2	87
191	Maligne Tumoren des Gehirns	0 / 0,2	—	4 / 0,6	822	1 / 0,3	364
410-414	Ischaemische Herzkrankheiten	7 / 9,7	112	46 / 31,7	164**	43 / 28	167**
410	Akuter Herzmuskelinfarkt	5 / 7,9	95	33 / 25	149*	31 / 22	154*
430-438	Cerebrovaskuläre Krankheiten	1 / 3,7	37	6 / 14,2	46	16 / 11,8	140
490-493	Bronchitis, Emphysem und Asthma	0 / 1,9	—	3 / 7	47	1 / 5,3	19
571	Leberzirrhose	2 / 2,2	126	7 / 6,7	118	5 / 6,5	86
800-949	Unfälle	4 / 7	88	19 / 17,7	127	9 / 10,8	95
950-959	Suizid und Selbstbeschädigung	0 / 3,5	—	8 / 9,5	98	7 / 5,9	137
011	Lungentuberkulose	0 / 0,9	—	0 / 2,7	—	0 / 1,2	—

*) Überschreitung des 95%-Vertrauensbereichs
**) Überschreitung des 99%-Vertrauensbereichs
(J. C. BAILAR: Significance Factors for the Ratio of a Poisson Variable to its Expectation. Biometrics 20: 639-643, 1964)

ab. 14. SMR acc. exposure duration for workers from PVC processing (cohort 3) observation period
Beobachtungszeitraum

		— 12		13 - 60		61 - 120		121 +	
ICD	Diagnose	Beob.-wert Erw.-wert	SMR	Beob.-wert Erw.-wert	SMR	Beob.-wert Erw.-wert	SMR	Beob.-wert Erw.-wert	SMR
	Gesamtmortalität	45 39,5	114	112 109,8	102	85 93,1	91**	118 137,3	86**
140-209	Maligne Tumoren der Organe und systematische Malignome	3 7,3	42	17 20,3	88	18 20,3	102	24 32,0	81
140-199	Maligne Tumoren	3 6,6	46	17 20,4	96	18 18,8	110	22 29,9	80
200-209	Tumoren des lymphatischen und haematopoetischen Gewebes	0 0,7	—	0 1,9	—	0 1,5	—	2 2,1	102
150-159	Maligne Tumoren der Verdauungsorgane	0 2,6	—	6 8,2	85	7 7,6	103	2 11,9	18**
151	Maligne Tumoren des Magens	0 1,2	—	2 3,7	63	3 3,4	95	2 5,2	41
153	Maligne Tumoren des Dickdarms	0 0,5**	—	1 1,5	95	0 1,3	—	0 2,1	—
155	Maligne Tumoren der Leber	0 0,07	—	2 0,2	1094*	1 0,2	580	0 0,3	—
160-163	Maligne Tumoren des respiratorischen Systems	2 2	105	8 6,3	147	6 6	110	9 10,1	95
162	Maligne Tumoren der Trachea, Bronchien und Lunge	2 1,8	114	8 5,8	159	5 5,6	97	9 9,4	102
188	Maligne Tumoren der Harnblase	0 0,2	—	0 0,7	—	0 0,7	—	2 1,1	187
191	Maligne Tumoren des Gehirns	0 0,1	—	1 0,3	336	2 0,3	845*	2 0,3	690
410-414	Ischaemische Herzkrankheiten	6 6	112	31 18,5	195**	23 17,1	157	36 27,9	144*
410	Akuter Herzmuskelinfarkt	5 4,8	119	20 14,5	161	18 13,5	152	26 22,2	132
430-438	Cerebrovaskuläre Krankheiten	2 2,5	98	9 8,3	115	5 7,5	69	7 11,4	64
490-493	Bronchitis, Emphysem und Asthma	0 1,1	—	3 3,8	85	0 3,6	—	1 5,7	19
571	Leberzirrhose	2 1,5	161	3 4,2	87	3 3,7	88	6 5,9	116
800-949	Unfälle	7 6,1	142	9 12,9	88	6 8,2	89	10 8,3	138
950-959	Suizid und Selbstbeschädigung	4 2,9	168	6 6,5	108	1 4,6	24	4 5,3	90
011	Lungentuberkulose	0 0,5	—	0 1,4	—	0 1,3	—	0 1,6	—

*) Überschreitung des 95%-Vertrauensbereichs
**) Überschreitung des 99%-Vertrauensbereichs
(J. C. BAILAR: Significance Factors for the Ratio of a Poisson Variable to its Expectation. Biometrics 20: 639-643, 1964)

Tab. 14: SMR nach Expositionsdauer bei Arbeiten aus der PVC-Weiterverarbeitung (Kohorte III)

Tab. 15. SMR acc. age classes for workers from PVC processing (cohort 3)

ICD	Diagnose	Altersklassen — 24 Beob-achtungs-wert / Erwar-tungs-wert	SMR	25 — 34 Beob-achtungs-wert / Erwar-tungs-wert	SMR	35 — 44 Beob-achtungs-wert / Erwar-tungs-wert	SMR	45 — 54 Beob-achtungs-wert / Erwar-tungs-wert	SMR	55 — 64 Beob-achtungs-wert / Erwar-tungs-wert	SMR	65 + Beob-achtungs-wert / Erwar-tungs-wen	SMR
	Gesamtmortalität	8 / 8,5	94	28 / 27,4	102	44 / 43,6	101	61 / 71,4	85	106 / 117,1	91	113 / 111,7	101
140 - 209	Maligne Tumoren der Organe und systematische Malignome	1 / 0,5	287	3 / 2,6	129	5 / 6,5	96	10 / 15,7	75	22 / 29,8	80	21 / 26,6	84
140 - 199	Maligne Tumoren	1 / 0,3	478	3 / 1,9	177	5 / 5,4	115	10 / 14,4	82	21 / 28,1	81	20 / 25,4	84
200 - 209	Tumoren des lymphatischen und haematopoetischen Gewebes	0 / 0,2	—	0 / 0,7	—	0 / 1,1	—	0 / 1,3	—	1 / 1,7	60	1 / 1,2	91
150 - 159	Maligne Tumoren der Verdauungsorgane und des Peritoneums	0 / 0,05	—	1 / 0,5	216	2 / 2,2	120	1 / 6	19	6 / 11	61	5 / 10,5	51
151	Maligne Tumoren des Magens	0 / 0,02	—	0 / 0,2	—	1 / 0,9	139	0 / 2,7	—	5 / 4,9	109	1 / 4,8	23
153	Maligne Tumoren des Dickdarms	0 / 0,02	—	0 / 0,1	—	1 / 0,5	299	0 / 1	—	0 / 1,8	—	0 / 1,9	—
155	Maligne Tumoren der Leber	0 / 0,0007	—	1 / 0,01	7710* / 0,07	0 / —	— / 0,2	1	725* / 0,3	0 / —	— / 0,2	1	506
160 - 163	Maligne Tumoren des respiratorischen Systems	0 / 0,03	—	0 / 0,2	—	2 / 1,2	208	4 / 4,6	105	13 / 10,3	135	6 / 8,2	78
162	Maligne Tumoren der Trachea, Bronchien und Lunge	0 / 0,03	—	0 / 0,1	—	1 / 1	118	4 / 4,2	114	13 / 9,6	145	6 / 7,5	84
188	Maligne Tumoren der Harnblase	0 / 0,002	—	0 / 0,01	—	0 / 0,2	—	0 / 0,4	—	0 / 1	—	2 / 1,2	181
191	Maligne Tumoren des Gehirns	0 / 0,02	—	1 / 0,1	964	0 / 0,3	—	3 / 0,3	1099**	1 / 0,3	370	0 / 0,06	—
410 - 414	Ischaemische Herzkrankheiten	0 / 0,04	—	3 / 0,8	431	8 / 5,5	194	21 / 14,8	169*	27 / 26	113	37 / 22,3	184**
410	Akuter Herzmuskelinfarkt	0 / 0,04	—	2 / 0,7	312	8 / 4,9	218	13 / 12,8	122	22 / 21,1	114	24 / 15,5	169*
430 - 438	Cerebrovasculäre Krankheiten	0 / 0,05	—	0 / 0,5	—	0 / 1,3	—	1 / 3,3	33	9 / 9	110	13 / 15,6	86
490 - 493	Bronchitis, Emphysem und Asthma	0 / 0,03	—	0 / 0,2	—	0 / 0,5	—	0 / 1,6	—	1 / 5,1	21	3 / 6,8	47
571	Leberzirrhose	0 / 0,03	—	0 / 0,6	—	2 / 2,4	107	2 / 4,1	63	7 / 5,2	150	3 / 3	107
800 - 949	Unfälle	3 / 4,3	94	9 / 9,6	107	6 / 8,2	103	7 / 6	142	3 / 4,9	72	4 / 2,6	162
950 - 959	Suizid und Selbstbeschädigung	0 / 1,1	—	2 / 4,4	53	4 / 5,1	102	3 / 4,3	82	3 / 3	107	3 / 1	306
011	Lungentuberkulose	0 / 0,01	—	0 / 0,2	—	0 / 0,8	—	0 / 1,2	—	0 / 1,5	—	0 / 1	—

*Überschreitung des 95%-Vertrauensbereichs **Überschreitung des 99%-Vertrauensbereich
(J. C. Bailar: Significance Factors for the Ratio of a Poisson Variable to its Expectation. Biometrics 20:639-643, 1964)

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