A Retrospective Cohort Mortality Study of Workers at an Electric Capacitor Plant Utilizing Polychlorinated Biphenyls

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Presented here are the results from a retrospective cohort mortality study of workers at an electric capacitor manufacturing plant that used polychlorinated biphenyls (PCBs). A cross-sectional study of workers from this plant has previously been reported.[1] PCBs are a class of compounds composed of biphenyl molecules with a varying number of substituted chlorine atoms. PCBs were widely used as a dielectric compound in electrical capacitors and transformers. They were also used in: heat exchange units, hydraulic systems, vacuum pumps, and fluorescent lighting fixtures. PCBs were manufactured by Monsanto in the United States from 1929 until 1977. In the United States production, sale and distribution of PCBs was ended in 1979. PCBs have been shown to be carcinogenic in animal studies, primarily effecting the liver. Evidence for human carcinogenicity is not well established. Previous reports of humans exposed to PCBs have reported increased risks of liver and biliary cancer, cancer of the rectum, hematopoietic malignancies, and malignant melanoma.[2-4]

Description of the facility

The study population worked at an electric capacitor plant located in the state of Indiana in the mid-west United States. The plant began operations in 1937. Production of electric capacitors containing PCBs began in 1939. Aroclor (Monsanto trade name) 1242 was used from 1939 to 1971 and Aroclor 1016 was used after 1971. Both mixtures contained 42% polychlorinated biphenyls, the difference being that Aroclor 1016 had fewer biphenyl homologues with 5 or more chlorine atoms per biphenyl nucleus. In 1977, the dielectric fluid was switched from PCBs to isopropyl biphenyl. In 1977, there were 429 current active hourly employees (327 men and 102 women), and 153 salaried employees (117 men and 36 women).

Manufacture of capacitors involved the production of bails made from foil, paper, and plastic which were placed into metal capacitor boxes. Several capacitors were then bound together, placed into a vacuum chamber, and heated to 150°C to remove moisture. The vacuum chambers were then flooded with dielectric fluid to fill and impregnate the capacitors. After five days, the remaining fluid was pumped out and filtered for reuse. The doors of the ovens were opened and the capacitors removed. Fill-holes in the capacitors were then plugged and soldered shut. Capacitors were subsequently degreased and spray-painted. Approximately 10% of the workforce was directly involved in capacitor manufacturing and these workers had the greatest potential exposure to PCBs. Other chemical exposures at the plant included toluene, xylene, methyl ethyl ketone, trichloroethylene, and 1,1,1-trichloroethane.

Methods and Materials

Included in this analysis are 3575 white male and female workers ever employed at this facility between January 1, 1937, when the plant opened, and March 31, 1977, the year when PCB use was discontinued. All workers were included, regardless of their job or exposure to PCBs. All personnel records and all death records in possession of the company were microfilmed and abstracted for name, date of birth, sex, race, social security number, and detailed job history. Workers whose race was unknown (88%) were considered to be white.

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Nonwhite workers were excluded from the analysis. Also excluded were persons for whom dates of birth or hire were missing. Job histories were used to identify the date of first employment and the date of last employment. Date of first employment at the plant was considered the first day of exposure. The last day of exposure was March 31, 1977 or the actual last day of employment, whichever was earlier.

Vital status as of June 30, 1986 was determined through the Social Security Administration (SSA) for all those known to be deceased. Copies of all death certificates were requested from the respective state Vital Statistics offices and the underlying cause of death determined by a qualified nosologist according to the International Classification of Diseases in effect at the time of death. Those whose vital status was unknown and those who died after June 30, 1986 were considered to be alive for the purpose of this analysis.

Person-years at-risk of dying were accumulated for each worker starting January 1, 1957 or on their first day of employment at the plant whichever occurred later and continued until the date of death or the study end date (June 30, 1986), whichever occurred first. The NIOSH life table computer program was used to combine sex and race-specific person-years at-risk into five-year calendar time periods and five-year age groups.[5] Expected numbers of cause-specific deaths were calculated by multiplying the age, sex, and calendar time specific United States mortality rates by the corresponding number of person-years at-risk. Person-years at-risk were additionally stratified into five-year employment and latency categories. Latency was defined as time from the first day of employment until the date of death or the study end date, whichever came first. The number of observed cause-specific deaths was divided by the number of expected cause-specific deaths to yield a Standardized Mortality Ratio (SMR). Ninety-five percent confidence intervals around the SMR were calculated using an approximation based on the Poisson distribution.[6]

To confirm cause of death and to establish the date of diagnosis for selected tumors, medical records and pathology reports were collected when available

Results

The entire cohort included 3644 workers; the majority of whom were white males (N=2736) or white females (N=847).(Table I) Fourteen nonwhites were excluded. In addition, 55 whites were excluded because of either an unknown date of first employment or date of birth, or they did not work between January 1, 1937 and March 31, 1977. This left 3575 persons in the final cohort to be analysed. Of these, 191 were dead and 3384 were considered to be alive at the study end date.

The 3575 workers included in the final cohort had a total of 71,909 person-years at-risk.(Table II) Thirty-two percent of the person-years were included in the six months duration of employment strata and an additional 43 percent of the person-years are accounted for by the six months to four years duration of employment category. Only four percent of the total person-years are included in the 15 years or greater duration of employment category. Seventy-five percent of the person-years are included in latency strata in excess of five years.

Overall mortality was less than expected for both sexes combined (observed=191: SMR=0.76; 95% CI 0.58 - 0.78).(Table III) The SMR for all cancers was also below expected (observed=54: SMR=0.85; 95% CI 0.64 - 1.11).

Fewer deaths were observed than expected for cancers of the digestive system (observed=8: SMR=0.57; 95% CI 0.25 - 1.14) with the exception of cancer of the biliary passages, liver, and gall bladder (1 observed: SMR=1.14; 95% CI 0.01 - 6.18). There were seven observed deaths from cancer of the hematopoietic tissues (SMR=0.97; 95% CI 0.39 - 2.01). The SMR for deaths due to cancer of the skin was significantly elevated (8 observed: SMR=4.06; 95% CI 1.75 - 8.01). All eight skin cancer deaths had an underlying cause of death from malignant melanoma. The SMR for cancer of the brain and nervous system was also elevated (5 observed: SMR=1.80, 0.58 - 4.22), but this elevation was not statistically significant. Death from diseases of the heart, the respiratory system, accidents, and violence were all well below expected.

The distribution of the skin cancer deaths and the brain cancer deaths were then distributed by latency and exposure (duration of employment) categories and the SMRs were calculated for each category. All melanoma deaths occurred at least five years after employment began and the risk of mortality remained relatively stable after 5 years of latency.(Table IV) Two of the malignant melanoma deaths occurred in individuals with less than six months duration of employment and two others had worked between six months and five years. The SMR for skin cancer mortality was greatest for person-years accumulated with 10-14 years of duration of employment (3 observed, 0.23 expected). All five deaths occurred five or more years after initial employment.(Table V) One brain cancer death occurred in an individual with less than six months duration of employment. The remaining four deaths occurred in workers with five or more years employment. The SMR for brain cancer was greatest for person-years accumulated with 10-14 years duration of exposure (2 observed, 0.34 expected).

The cohort was stratified by gender to examine the consistency of the findings of excess mortality from skin cancer and cancer of the brain and nervous system. White men were at excess risk of mortality from skin cancer (6 observed: SMR=3.63; 95% CI 1.32 - 7.90) and cancer of the brain and central nervous system (4 observed: SMR=1.76; 95% CI 0.48 - 4.50) (Table VI). White women were also at excess risk of death from skin cancer (2 observed: SMR=4.63; 95% CI 0.70 - 22.57) and cancer of the brain and central nervous system (1 observed: SMR=2.01; 95% CI 0.05 - 11.21) (Table VII).

Discussion

This study did not confirm the excess in deaths from hematopoietic cancers or cancer of the digestive system observed in a cohort of capacitor manufacturing workers exposed to PCBs (Aroclor 1254 and Pyralene 1476) studied by Bertazzi et al.[2] In that study, 2100 men and women workers who worked for a minimum of one week between 1956 and 1970 were included. For men, there were excesses in cancer of the G.I. tract (6 observed, 1.7 expected), hematopoietic neoplasms (3 observed, 0.8 expected), and cancer of the lung (3 observed, 1.2 expected). Women experienced excess mortality from hematopoietic neoplasms (4 observed, 1.5 expected).

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Brown also studied capacitor workers exposed to PCBs (Aroclor 1254, 1242, and 1016).[3] He followed 2367 workers employed a minimum of three months in "PCB exposed" jobs at two electrical capacitor manufacturing plants. Workers in other jobs were not included in the cohort. Brown found an increased risk of death from cancer of the biliary passages, liver, and gall bladder (5 observed, 1.9 expected). The study presented here also found an excess mortality risk for this cancer site, however this represented only one death.

Brown also reported excess mortality from cancer of the rectum (4 observed, 1.9 expected) which was not observed in this study. At least one other cohort of capacitor workers exposed to PCBs has been studied. Gustavsson et al reported on a small cohort of 142 workers employed at least six months between 1965 and 1978 at a Swedish capacitor plant using PCBs (chlorinated to 42%).[7] Seven incident cancers were observed (5.39 expected) between 1965 and 1980. Zack and Munch followed a small cohort of 89 workers exposed to PCBs at a plant that manufactured PCBs in the United States. These workers were exposed for a minimum of six months between 1945 and 1965.[8] They reported an overall excess in mortality (30 deaths observed, 22.9 expected) and all malignant neoplasms (8 observed, 4 expected). One death from cancer of the lymphatic and hematopoietic tissue was reported (0.4 expected).

The major finding reported in this study is the dramatic excess mortality from cancer of the skin. This finding is further remarkable since the underlying cause for all eight deaths was malignant melanoma. In the United States between 1970-1979, malignant melanoma accounted for 70% of the mortality from all skin cancers in white men.[9] Furthermore, the death certificate of a ninth cohort member had malignant melanoma listed as a contributory cause. This excess mortality from malignant melanoma should be interpreted with caution. None of the retrospective cohort studies described above reported deaths caused by malignant melanoma. Even so, the association between exposure to PCBs and malignant melanoma has been described previously in the literature.[4] Bahn et al reported a preliminary investigation of workers exposed to PCBs at a petrochemical plant. Two incident cases of malignant melanoma were observed among 31 "heavily" exposed (research and development) employees (0.04 expected) and an additional melanoma was observed among 41 workers with lower exposure to PCBs (refinery workers). Details regarding study methods, workplace exposures, latency, and duration of exposure were not reported and it is not possible to adequately assess this report. Schecter reported one case of malignant melanoma among approximately 500 workers potentially exposed to PCB, dioxin, and dibenzofuran following an electric transformer fire in an office building.[10] Indirect supporting evidence comes from the association between malignant melanoma risk and occupational exposures to fluorescent lighting.[11-13] At least one researcher has hypothesized that this association may be explained by exposures to PCBs, used as a dielectric fluid in the small capacitors found in fluorescent light fixtures, following a "burnout" of the light fixture.[14]

The increased malignant melanoma death risk seen in this cohort may have been the result of other risk factors such as ethnicity, that are specific to the geographic location of the plant. However, there is little evidence to support this. The malignant melanoma mortality rates for all counties in the United States from 1950-1979 have been published.[9] The mortality rates for the United States as a whole, the state of Indiana, and the county where the plant is located were compared. These rates do not demonstrate an increased risk of death from malignant melanoma for the county when compared to either

Indiana or the United States.(Table VIII) White women in the county were reported to have had a statistically significant excess malignant melanoma death rate during the decade 1950-1959 (7 deaths observed, less than 2 expected). However, this excess was not observed during the next two decades and was not observed for men.

Pathology reports were obtained and confirmed the diagnosis for eight of the nine deaths reporting malignant melanoma as an underlying or contributory cause.(Table IX) The pathology report for the ninth malignant melanoma was not obtained, however the medical record did substantiate this diagnosis. One of the cases was diagnosed two months before starting to work at the capacitor plant. This worker was employed for approximately ten years and died of metastatic malignant melanoma 14 years after the original diagnosis.

The excess risk of mortality from cancer of the brain and nervous system has not been previously reported for capacitor manufacturing workers exposed to PCBs. The excess reported here was not statistically significant and may represent a chance finding. In addition to the five brain cancer deaths analyzed in this cohort, it should be noted that three additional workers in this cohort are known to have died having had brain cancer. Brain cancer was noted as a contributory cause of death on one death certificate, and was the underlying cause of death in one worker who died after the study end date and in another worker who was excluded because of race. The pathology records for two of the eight brain cancers were obtained.(Table IX) One tumor was classified as a meningioma and the second as a glioblastoma. Medical records indicated that two other tumors were glioblastomas and another two were astrocytomas. Pathology reports were not obtained for these four tumors.

This study had several limitations. We assumed that persons whose vital status was unknown (13%) remained alive until the study-end date. This assumption could result in a conservative bias; not only over-estimating the person-years at-risk but also failing to identify deaths among the cohort members. We also assumed that workers were white if their race was unknown. This would seem to be reasonable given that 96% of the workforce, whose race was known, were white. The direction of the bias any racial misclassification would have caused would have varied from one specific cause of death to another. A conservative bias would have occurred for malignant melanoma since whites are at greater risk of death than are nonwhites.[9] Finally, very little information was available concerning other exposures at the facility.

The results presented here should not be interpreted as demonstrating a causal relationship between PCBs and either malignant melanoma or cancers of the brain and nervous system. Rather, the results reflect the risk of death for all persons working at this facility while PCBs were in use. Environmental and biologic data collected in 1977 indicated that most workers at the plant had been exposed to PCBs.[1] Serum PCB levels collected at that time from a cross-sectional sample of workers ranged from 3 times (workers not directly exposed to PCBs) to 50 times (workers with direct exposure) the background level of 11.6 ng/ml, determined in another study for community residents with no known occupational or unusual exposure to PCBs. The serum PCB data collected in 1977 will be used to create a job-exposure matrix which will be used to estimate cause-specific mortality rates based on specific job titles and potential exposure to PCBs.

Summary

Fewer deaths from all causes and from all cancers combined were observed than expected among workers employed at a capacitor manufacturing plant using PCBs in the production process. Mortality from skin cancer was four times that expected and mortality from cancer of the brain was 1.8 times that expected. Risk of death from these causes was consistent for both men and women. Risk of death from both skin cancer and cancer of the brain and nervous system were highest for person-years accumulated with 10-14 years duration of employment at the plant and none of the deaths occurred within the first five years after hire. These findings contrast sharply with several other studies of workers exposed to PCBs in capacitor manufacturing plants and should be interpreted with caution. Further analyses will take into consideration specific jobs by incorporating a job-exposure matrix based on environmental and biologic sampling for PCBs collected in 1977 at this plant.

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Table I:
Cohort Status Breakdown and Vital Status

A. Cohort Status Breakdown

Sex/Race	Total Cohort	Rejected*	Final Cohort
White Males	2783	47	2736
White Females	847	8	839
Nonwhite Males	11	11	0
Nonwhite Females	3	3	0
Total	3644	69	3575

B. Vital Status

Vital Status	Total Cohort	Rejected	Final Cohort**
Alive	2946	52	3384
Dead	217	9	191
Unknown	481	8	***
Total	3644	69	3575

* Rejected from analysis because of an unknown date of first employment, not employed between January 1, 1957 and March 31, 1977, or race is nonwhite.

** 473 workers with a vital status unknown were included in the analysis and considered to be alive as of June 30, 1986.

*** 17 workers died after June 30, 1986 and were considered to be alive at the study end date.

Table II
Distribution of Person Years by Latency and Duration of Employment; All Whites Combined.

LATENCY	DURATION OF EMPLOYMENT 1 day- 5 months	6 months- 4 years	5 years- 9 years	10 years- 14 years	15 years +	Total
1 day- 4 years	6984	10814				17797
5 years- 9 years	5759	7005	4922			17686
10 years- 14 years	5402	6461	2016	2843		16722
15 years- 19 years	3868	4495	1531	1523	1223	12641
20 years- 24 years	929	1896	698	570	1180	5274
25 years +	240	566	314	87	582	1789
Total	23180	31238	9482	5023	2985	71909

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Table III
Summary of Observed and Expected Deaths
All Whites Combined

Underlying Cause of Death	Observed Deaths	Expected Deaths	Ratio	95% C.I. Lower	Upper
All Causes	191	283.5	0.67**	0.58 -	0.78
All Cancers	54	63.4	0.85	0.64 -	1.11
Site Specific Cancers					
Buccal Cavity & Pharynx	0	1.6	----		
Digestive Organs & Peritoneum	8	13.8	0.57	0.25 -	1.14
Biliary Passages, Liver and Gall Bladder	1	0.9	1.14	0.01 -	6.18
Pancreas	2	2.8	0.70	0.08 -	2.55
Rectum	1	1.2	0.81	0.04 -	7.29
Respiratory System	15	20.2	0.74	0.42 -	1.23
Urinary System	2	2.5	0.81	0.49 -	1.35
Lymphatic & Hematopoietic	7	7.2	0.97	0.39 -	2.01
Skin[@]	8	2.0	4.06**	1.75 -	8.01
Brain and Nervous System**	5	2.8	1.80	0.58 -	4.22
All other sites combined	5	8.4	0.60	0.19 -	1.39
Diseases of the Heart	59	85.4	0.69**	0.52 -	0.89
Diseases of the Respiratory System	10	12.3	0.81	0.39 -	1.50
Accidents	27	41.3	0.65*	0.43 -	0.95
Violence	14	21.5	0.65	0.36 -	1.09

* - p less than 0.05; ** - p less than 0.01.

@ - Expected number of deaths were calculated using mortality rates for basal cell carcinoma, squamous cell carcinoma, and malignant melanoma combined. All observed skin cancer deaths were malignant melanomas.

**- Cancer of the brain and central nervous system included the following ICD codes: ICD 193 (6th & 7th revision); ICD 191, 192 (8th & 9th revision).

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Table IV
Distribution of Observed and Expected Deaths
by Latency and Duration of Employment.
Malignancy of the Skin
All Whites Combined

LATENCY	DURATION OF EMPLOYMENT 1 day- 5 months	6 months- 4 years	5 years- 9 years	10 years- 14 years	15 years +	Total
1 day- 4 years	0	0				0
	0.07	0.14				0.22
	0.00	0.00				0.00
5 years- 9 years	1	0	1			2
	0.10	0.12	0.11			0.34
	10.02	0.00	8.81			5.96
10 years- 14 years	1	0	0	2		3
	0.14	0.17	0.06	0.10		0.47
	6.98	0.00	0.00	19.58**		6.38*
15 years- 19 years	0	1	0	1	0	2
	0.15	0.17	0.06	0.08	0.06	0.52
	0.00	5.96	0.00	12.33	0.00	3.86
20 years- 24 years	0	0	0	0	0	0
	0.05	0.10	0.04	0.04	0.08	0.30
	0.00	0.00	0.00	0.00	0.00	0.00
25 years +	0	1	0	0	0	1
	0.02	0.03	0.02	0.01	0.05	0.13
	0.00	29.85	0.00	0.00	0.00	7.99
Total	2	2	1	3	0	8
	0.53	0.73	0.29	0.23	0.18	1.97
	3.76	2.74	3.45	12.82**	0.00	4.06**

Expected number of deaths calculated for basal cell carcinoma, squamous cell carcinoma, and malignant melanoma combined. All observed skin cancer deaths were malignant melanoma.
* - p less than 0.05; ** - p less than 0.01

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Table V
Distribution of Observed and Expected Deaths
by Latency and Duration of Employment.
Malignancy of the Brain and Nervous System
All Whites Combined

	DURATION OF EMPLOYMENT					
LATENCY	1 day- 5 months	6 months- 4 years	5 years- 9 years	10 years- 14 years	15 years +	Total
1 day- 4 years	0 0.13 0.00	0 0.24 0.00				0 0.37 0.00
5 years- 9 years	1 0.14 7.16	0 0.17 0.00	1 0.18 5.42			2 0.50 4.03
10 years- 14 years	0 0.18 0.00	0 0.21 0.00	0 0.08 0.00	1 0.17 6.05		1 0.64 1.57
15 years- 19 years	0 0.18 0.00	0 0.21 0.00	0 0.08 0.00	1 0.11 9.03	1 0.09 10.68	2 0.67 2.97
20 years- 24 years	0 0.07 0.00	0 0.13 0.00	0 0.05 0.00	0 0.06 0.00	0 0.11 0.00	0 0.41 0.00
25 years +	0 0.02 0.00	0 0.05 0.00	0 0.03 0.00	0 0.01 0.00	0 0.06 0.00	0 0.18 0.00
Total	1 0.72 1.39	0 1.01 0.00	1 0.42 2.37	2 0.34 5.82	1 0.27 3.65	5 2.77 1.80

**- Cancer of the brain and central nervous system included the following ICD codes: ICD 193 (6th & 7th revision); ICD 191, 192 (8th & 9th revision).

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Table VI
Summary of Observed and Expected Deaths
White Men

Underlying Cause of Death	Observed Deaths	Expected Deaths	Ratio	95% C.I. Lower - Upper
All Causes	168	243.8	0.68**	0.59 - 0.80
All Cancers	44	49.0	0.89	0.65 - 1.20
Site Specific Cancers				
Buccal Cavity & Pharynx	0	1.5	-----	
Digestive Organs & Peritoneum	6	11.4	0.52	0.19 - 1.15
Biliary Passages, Liver and Gall Bladder	1	0.7	1.45	0.02 - 7.95
Pancreas	2	2.4	0.84	0.10 - 3.05
Rectum	0	1.0	-----	
Respiratory System	15	17.8	0.84	0.47 - 1.39
Urinary System	2	2.2	0.92	0.11 - 3.32
Lymphatic & Hematopoietic	5	6.0	0.83	0.27 - 1.96
Skin@	6	1.7	3.63*	1.32 - 7.90
Brain and Nervous System***	4	2.3	1.76	0.48 - 4.50
All other sites combined	3	2.0	1.50	0.30 - 4.38
Diseases of the Heart	58	77.7	0.74*	0.57 - 0.96
Diseases of the Respiratory System	6	10.5	0.57	0.21 - 1.25
Accidents	24	38.2	0.62*	0.40 - 0.94
Violence	12	19.4	0.61	0.32 - 1.08

* - p less than 0.05; ** - p less than 0.01

@ - Includes basal cell carcinoma, squamous cell carcinoma, and malignant melanoma.

*** Cancer of the brain and central nervous system included the following ICD codes: ICD 193 (6th & 7th revision); ICD 191-192 (8th & 9th revision).

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Table VII
Summary of Observed and Expected Deaths
White Women

Underlying Cause of Death	Observed Deaths	Expected Deaths	Ratio	95% C.I. Lower	Upper
All Causes	23	39.6	0.58**	0.37	- 0.87
All Cancers	10	14.4	0.69	0.33	- 1.27
Site Specific Cancers					
Buccal Cavity & Pharynx	0	0.18	----		
Digestive Organs & Peritoneum	2	2.46	0.81	0.10	- 2.93
Biliary Passages, Liver and Gall Bladder, and unspecified Liver	0	0.18	----		
Pancreas	0	0.47	----		
Rectum	1	0.21	4.69	0.06	- 26.49
Respiratory System	0	2.40	----		
Urinary System	0	0.28	----		
Lymphatic & Hematopoietic	2	1.24	1.61	0.20	- 5.84
Skin@	2	0.32	6.33	0.70	- 22.97
Brain and Nervous System***	1	0.50	2.01	0.05	- 11.21
All other sites combined	2	6.34	0.32	0.00	- 4.92
Diseases of the Heart	1	7.71	0.12**	0.00	- 0.72
Diseases of the Respiratory System	4	1.78	2.24	0.61	- 5.74
Accidents	3	3.11	0.96	0.20	- 2.81
Violence	2	2.12	0.94	0.11	- 3.4

* - Statistically significant (p less than 0.05).
@ - Calculation of expected number of skin cancer deaths includes basal cell carcinoma, squamous cell carcinoma, and malignant melanoma. All observed skin cancer deaths were caused by malignant melanoma.
*** Cancer of the brain and central nervous system included the following ICD codes: ICD 193 (6th & 7th revision); ICD 1917 192 (8th & 9th revision).

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Table VIII

Skin Cancer

Mortality Rates per 100,000 White Males and White Females, United States, Indiana, and Monroe County; By Decade (1950-1979)

Decade	United States N	United States rate	Indiana N	Indiana rate	Monroe County N	Monroe County Rate
			Malignant Melanoma			
			White Males			
1950-1959	9088	1.3	200	1.0	3	1.8
1960-1969	14337	1.8	329	1.6	3	1.4
1970-1979	21549	2.4	512	2.3	9	3.1
			White Females			
1950-1959	7566	1.0	182	0.9	7	3.4*
1960-1969	11297	1.2	275	1.1	4	1.4
1970-1979	16079	1.5	346	1.3	4	1.1

* Significantly more than expected deaths. Data from Riggan et al.[13]

Table IX
Descriptive Statistics of Malignant Melanoma and Brain Cancer Deaths.

Malignant Melanoma

Case	Sex	Age at death	Date of Hire	Date of DX or Death@	Microscopic Confirmation	Location of primary
A	F	37	02/58	09/67	Yes	anterior chest
B	M	44	06/58	01/75	Yes	scalp
C	M	43	03/59	01/67	Yes	gallbladder
D	M	52	04/66	08/78	Yes	neck
E	M	32	08/64	02/75@	NA	shoulder
F	M	47	05/59	10/80	Yes	back
G*	M	63	10/66	06/87	Yes	anterior chest
H	M	68	01/61	11/80	Yes	back
I	F	40	06/70	07/76	Yes	face and neck

* Malignant melanoma considered a contributory cause of death.
H began employment two months after diagnosis.

Cancer of the Brain and Nervous System

Case	Sex	Age at death	Date of Hire	Date of DX or Death@	Microscopic Examination	Histology
AA*	M	65	06/58	1983	Yes	meningioma
BB	M	66	08/74	11/81	NA	glioblastoma
CC	M	51	03/62	04/75@	NA	unknown
DD	F	52	01/59	12/74@	NA	unknown
EE*	M	45	08/62	03/86	Yes	glioblastoma
FF	M	67	11/59	04/76@	NA	astrocytoma
GG	M	34	07/58	10/64@	NA	astrocytoma
HH*	F	44	05/66	01/79@	NA	glioblastoma

* AA had a brain cancer considered to be a contributory cause of death, EE died of brain cancer after June 30, 1986, and HH was a nonwhite female and was excluded from analysis.

@ Date reported refers to the date of death.

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