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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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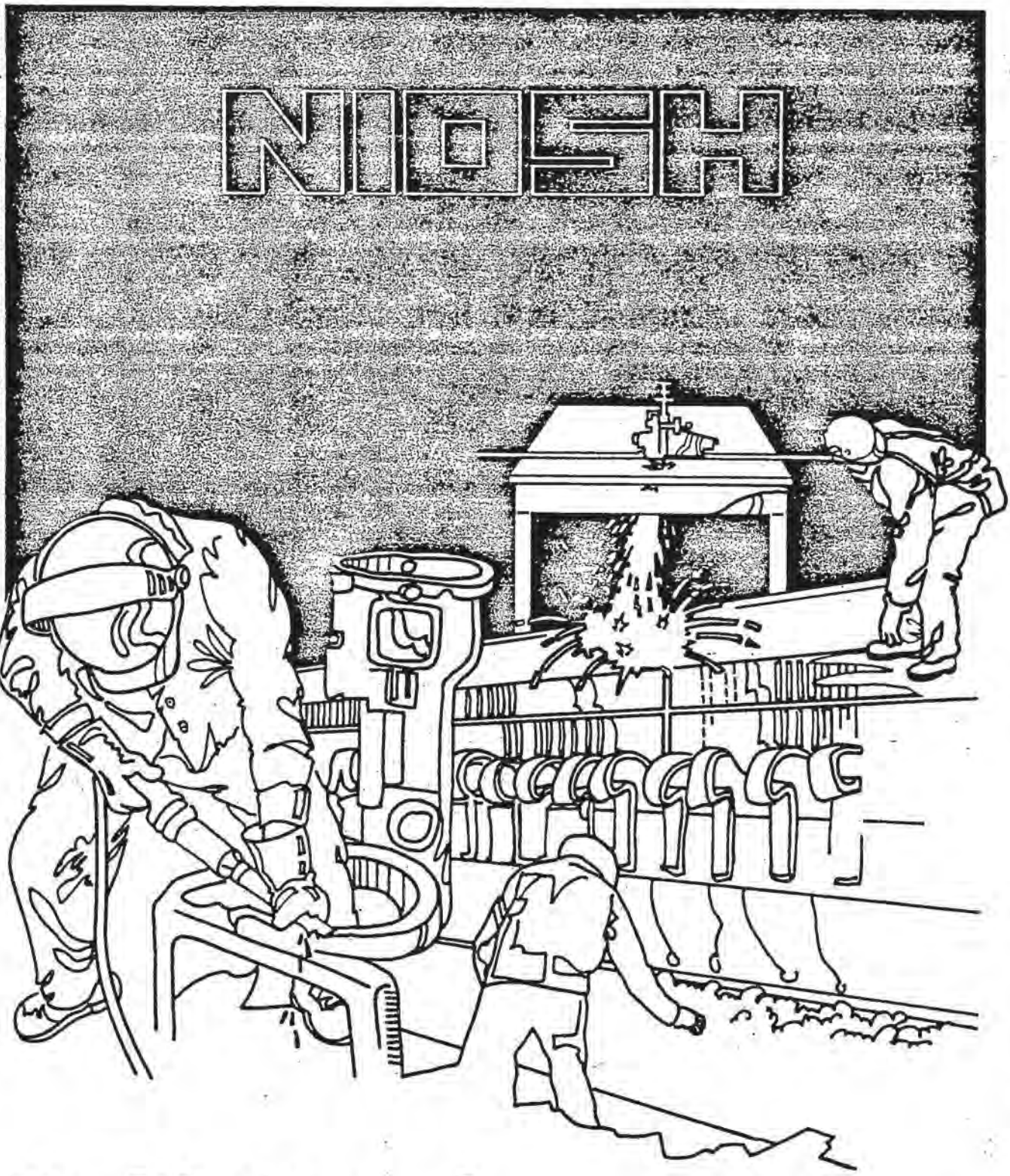

Health Hazard Evaluation Report

HETA 80-250-1529
DELCO ELECTRONICS DIVISION
MILWAUKEE, WISCONSIN

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 80-250-1529
NOVEMBER 1984
DELCO ELECTRONICS DIVISION
MILWAUKEE, WISCONSIN

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I. SUMMARY

On September 24, 1980, the National Institute for Occupational Safety and Health (NIOSH) was requested to investigate a possible excess of deaths from brain cancer among former employees at the Delco Electronics Division of General Motors (SIC 3662), Milwaukee, Wisconsin. Concern was also expressed about the potential effects of workplace exposure to trichloroethylene, beryllium, and balancing fluid (a halogenated aromatic hydrocarbon) in the Avionics Section of the plant.

To determine whether mortality from brain cancer was increased relative to other causes of death, a proportionate mortality ratio (PMR) study, a proportionate cancer mortality ratio (PCMR) study and a case control study were conducted using information obtained through the company death benefits program. The study participants for whom death information was available included only active workers, terminated employees who had worked 10 years, and disabled workers.

Proportionate cancer mortality from brain cancer was found to be approximately 2 times (11 observed vs. 5.63 expected) that which would be expected to occur in the United States general population. This result was statistically significant among male hourly workers, and elevated but not statistically significant among male salaried employees and among females. When the jobs of the workers with brain cancer were examined in a case control study, elevated risks for brain cancer were found among workers ever engaged in machining operations, maintenance or general office work relative to all other job categories. In this study, we were not able to identify a particular exposure which was associated with the excesses.

Based on the industrial hygiene evaluation and epidemiologic studies, it is concluded: 1) Current exposures to trichloroethylene, beryllium and balancing fluid are limited and have been within the applicable OSHA Standards. 2) Among the 504 deaths studied, there was a 2-fold increase in the proportionate cancer mortality (PCMR) from brain cancer (11 observed vs. 5.6 expected). More of these individuals worked in the machining and maintenance operations and as general office workers than those who died from other causes. 3) We do not have enough evidence to conclude that there is a hazard at this plant. The twofold excess of brain cancer may be a real effect of exposure in this plant. However, no substances identified at the plant have been associated with brain tumors and no exposure was identified as common to office workers, and also to machinists and maintenance workers. Additionally, the PCMR analysis has limitations which should be recognized, and the numbers in the case control study are small.

It is recommended that NIOSH should be notified if additional cases of brain cancer are observed at this plant.

KEYWORDS: SIC 3662 (Radio and Television Transmitting, Signaling, and Detection Equipment and Apparatus), BRAIN CANCER, PROPORTIONATE CANCER MORTALITY, BERYLLIUM, TRICHLOROETHYLENE.

II. INTRODUCTION

On September 24, 1980, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request for a Health Hazard Evaluation at the Delco Electronics Division of General Motors (SIC 3662), Milwaukee, Wisconsin to investigate a possible excess of deaths from brain cancer among former employees. The request stated that 16 employees had died of brain tumors since the opening of the plant. Concern was also expressed about the potential effects of workplace exposure to beryllium, trichloroethylene, and to a balancing fluid (the components of which are halogenated aromatic hydrocarbons).

An initial survey was conducted at Delco on November 19, 1980, by two NIOSH representatives; an epidemiologist and an industrial hygienist. The survey began with an opening conference with management and labor representatives followed by a walk-through of the HHE request area - Building 1A or Avionics. The industrial hygienist evaluated the processes and reviewed the plant history and past environmental evaluations with the plant Safety Director, UAW Health and Safety Representative, and the Delco industrial hygienist. The epidemiologist evaluated the suitability of the personnel, benefits, and medical records for use in epidemiologic studies that might be confidential and also reviewed with the GM Corporate and Delco Electronics Division Medical Officers death certificates and work histories of employees whose names were submitted to NIOSH by the requestor.

On November 20, 1980, a visit was made to the area OSHA office and files pertaining to past OSHA inspections at Delco were reviewed.

Inquiry was made into the locations and availability of past environmental sampling records and past process descriptions and job title associations in Avionics.

Two interim reports were released by NIOSH in January 1982 [1] and in August 1982.[2] These reports described the NIOSH evaluation of the reported cases of brain cancer, the preliminary results of the NIOSH industrial hygiene evaluation, and the preliminary findings of the proportionate mortality ratio (PMR) and proportionate cancer mortality ratio (PCMR) studies. This final report contains the final results of the NIOSH PMR and PCMR studies and of the NIOSH case-control investigation of brain cancer among employees of this Delco Electronics plant.

III. BACKGROUND

A. Facility and Workforce

Delco Electronics has occupied its present Oak Creek facility, a concrete block and steel single story building since it was built in 1958. Prior to 1958 the operations had been located in downtown Milwaukee and were known as AC Spark. The opening of the Oak Creek facility coincided with work performed for the Apollo Space Program and was accompanied by a precipitous increase in employment to a peak of 8800 employees in 1968.

Termination of the Apollo program resulted in a reduction in employment to 800 employees in 1973-74, remaining fairly constant until the late 70's when large portions of the facility were taken over for production of automotive parts.

The entire complex was initially involved in the space program but during the initial investigation the area dedicated to Avionics occupied only the original portion of the plant built in 1958. Facilities in other parts of the plant formerly used for Avionics had been removed to accomodate automotive production. The size and location of Avionics has been relatively unchanged since 1973.

At the time of the initial investigation approximately 2700 individuals were employed at the facility with about 700 employed in Avionics. The estimated number of individuals who had ever worked during the period 1950-1980 is 25,000.

B. Product

Delco Electronics manufactures precision inertial navigation systems (INS) for use by the aerospace and aviation industry. All parts used in the assembly of the INS are now purchased from outside contractors and assembled (with minor modifications where necessary) at the Oak Creek facility. About one third of the Avionics area is occupied by "clean rooms" where the navigation units of the system (specifically the gyros and accelerometers) are assembled. The gyros are made of pure beryllium metal.

C. Process Description

Parts coming in from suppliers used in the production of gyros are first brought to the beryllium machining and reclamation area for inspection. Here deburring, cleaning, and minor modifications on beryllium parts are made before they enter the clean rooms. Assembly of gyros and accelerometers takes place in the environmentally controlled clean rooms with the majority of assembly performed inside laminar flow hoods, some with stereoscopic microscopes. Degreasing is done using Freon in small vapor degreasers (most holding 1 liter or less) and rough balancing of the gyros is done in a small open bench top container (about 2 liter capacity). Fine balancing is done in a dummy housing. The gyros are then placed in the finished housing, which is filled with a flotation fluid having the same density as the gyro and is hermetically sealed. Final filling and sealing is done at an automatic fill station. The balancing fluid used on the bench top is a proprietary mixture of halogenated aromatic hydrocarbons. The memory area is where minute ferrite discs are hand strung together and various computer components are assembled. A small amount of soldering is done here. The stringing itself is done with the aid of stereoscopic microscopes.

Finished components from the clean rooms and memory area are assembled into the completed navigation unit (containing the gyros accelometer, and digital computer with memory) in the final assembly area. Here the control/display unit, mode selector unit, and battery unit are added. The completed navigation unit is then tested and calibrated.

The final stage of production is the testing of the gyros and accelerometer using a precision geodetic reference which is located on the plant premises. All INS testing is done with an array of computerized systems simulating normal operating conditions. The response of the unit is checked against the expected response.

D. Current Environmental Controls

Beryllium machining and reclamation area: Local exhaust hoods are located at all hand tool work stations. Slot hoods are located over small acid vats and lids on vats are in place. This area is under negative pressure, and workers are required to participate in medical surveillance programs and have beryllium clearance.

Clean rooms: Blowdown chamber and boot cleaners are located at the entrance to the area. Shoe covers, coveralls, and head covers are donned by employees in the break area. Employees wear virgin rubber finger cots or nylon mesh gloves with special palms when handling parts. Laminar flow hoods have "absolute" filters, with the air taken in at floor level and sent out through the hood. Vapor degreasers and minivats (small refrigeration units which are placed on top of 1000 ml beakers in which Freon is heated) are used for degreasing. All items entering and exiting clean rooms must pass through the "mud room", which interfaces the clean rooms with the rest of the plant. Clean rooms are interconnected and under positive pressure as well as being controlled for humidity and temperature. Tolerance for parts assembled in this area are on the order of millionths of an inch. Memory area: Soldering stations have small local exhaust slot hoods by the solder pots. Several paint booths with exhaust are used for quality control inspections. Several vapor degreasers were present in the area.

Final assembly and testing areas: No environmental controls other than for heating and cooling are required.

Miscellaneous: A machine shop adjacent to (but separate from) the beryllium machining and reclamation area is used for working on ferrite blanks (a material capable of holding a magnetic field) to machine ferrites used in the navigation units. Local exhaust is present on the larger equipment used in this shop.

All eating, drinking, and smoking is restricted to break areas outside of the assembly areas (including clean rooms).

IV. METHODS

A. Epidemiologic Studies

1. Proportionate Mortality Ratio (PMR) and Proportionate Cancer Mortality Ratio (PCMR) Studies:

   To determine whether excess cause-specific mortality (particularly brain cancer) existed, NIOSH conducted PMR and PCMR studies utilizing causes of death taken from death certificates

collected through the company death benefits program. This program is open to all active employees of Delco Electronics on a voluntary bases. According to company officials, approximately 99% of the total active workforce subscribes to the program. In addition, all pension (vested with 10 years employment) and disability benefit recipients receive the coverage under their benefits plan. Therefore, it is presumed that almost all deaths occurring between 1950 and 1980 among active, pensioned and disabled employees were known to the company and were included in the study. However, deaths of non-vested former employees (employed less than 10 years) who died subsequent to termination were not known to the company, and, therefore, were not included in the NIOSH studies.

Information used in the PMR and PCMR studies including name, social security number, cause of death and dates of birth and death were abstracted from death certificates and computerized. All death certificates were coded by a nosologist for cause of death according to the revision of the International Classification of Diseases in effect at the time of death. Finally, an indication each person's pay status (hourly or salaried) at their time of death was coded.

Calculation of PMRs was carried out by first computing the expected number of deaths for each five-year age and calendar period. This was accomplished by multiplying the age, sex and cause-specific proportionate mortality of the United States general population by the total number of workers in the study within each age, sex, and calendar period group, and then summing over all groups. Cause-specific PMR's were calculated by dividing the actual number of deaths by the expected number of deaths and multiplying by 100. Proportionate cancer mortality ratios (PCMR) were similarly computed using the age and calendar period specific proportionate cancer mortality of the United States white male and female populations for comparison. Differences in observed and expected numbers of death were tested for statistical significance using a 2-tailed 95% confidence limit assuming a Poisson distribution.

2. Case-Control Study of Brain Cancer Deaths:

To determine whether specific jobs were associated with the development of brain cancer, a case control study was conducted. Cases and controls were selected from the same study population used in the proportionate studies. The case series consisted of 11 individuals (9 males and 2 females) whose cause of death as indicated on the death certificate was malignant neoplasm of the brain.

For each case, four controls were chosen for whom the cause of death indicated on the death certificate was not cancer or benign neoplasm of the brain. Potential controls were ranked according to how closely they matched a case by age and by year first employed at the plant. The four controls who best matched a case were selected. Once selected as a control, an individual was not eligible for further selection. Controls must have been the same sex as the case and must have died subsequent to the case. A total of 44 controls was selected.

To obtain a measure of length of employment and a complete account of all jobs held by the cases and controls, the beginning and ending dates of each job and the related job titles were abstracted from work history records. A total of 125 different job titles appeared on the work records of the cases and controls. With the help of the company, we combined the titles into 27 job categories by grouping related job titles.

Odds ratios were calculated for each job category where at least three cases worked. The Mantel-Haenszel procedure for matched analysis[3] was used, and ninety-five percent confidence intervals were calculated using the test-based method to evaluate variation in the point estimate.

B. Industrial Hygiene

No industrial hygiene evaluation was undertaken, other than for the walk-through and historical review. Conditions in the workplace had undergone considerable change over the history of the process, making any direct comparison of present conditions to those of the past questionable. Historical data has been summarized in the Results section and was initially presented in Interim Report No. 1.[1]

V. RESULTS

A. Epidemiologic Studies

1. Proportionate Mortality Ratio Analysis:

For the period 1950-1980, a total of 508 employee deaths were identified from the company death benefits files. Five hundred and four deaths occurred among white employees, of which 412 were males and 92 were females. One hundred seventy-seven males and 13 females were classified as salaried employees at the time of death and 235 males and 79 females were classified as hourly employees. The average age at death was 58 years and 53 years for males and females, respectively. The distribution of deaths by year and age of death for the study population is illustrated in Table 1.

Four deaths were observed among black employees, but due to the small number of deaths, they were later excluded from the analysis. No brain cancer deaths occurred among these employees.

The analysis of the proportionate mortality ratio (PMR) study indicated that there were elevations in two categories of nonmalignant deaths, but they were not statistically significant. Among males, elevations were noted for disorders of the central nervous system (31 observed vs. 23.04 expected). This outcome was decreased among females (2 observed vs. 6.97 expected). Homicides and suicides were elevated among hourly male employees (12 observed vs. 7.95 expected) and females (5 observed vs. 1.11 expected). This cause of death was decreased among salaried male workers (1 observed vs. 7.38 expected). The results of the PMR analyses are presented in Tables 2 and 3. Elevations were also present for several types of cancer. Since these are more appropriately analyzed by proportionate cancer mortality ratio, the results are presented in the next section.

2. Proportionate Cancer Mortality Ratio

A statistically significant increase in death from brain cancer was found among male hourly employees (5 observed vs. 1.94 expected). Nonsignificant increases in brain cancer were observed among male salaried employees (4 observed vs. 2.44 expected) and among female employees (2 observed vs. 1.25 expected). These results are presented in Tables 4 and 5.

A statistically significant increase in stomach cancer was observed for female employees (Table 5), and nonsignificant elevations were also noted for several other types of cancer among male and female employees (Tables 4 and 5).

3. Case-Control Analysis:

This analysis was conducted to determine whether particular jobs or exposures were associated with the cases of brain cancer, of which 9 were male and 2 were female. With the exception of 2 cases, all were confirmed through either autopsy or tissue pathology (Table 6). The distribution by cell type included 6 cases of glioblastoma multiforme (5 males, 1 female), one case each of neurilemmoma, astrocytoma and pinealoma, and two of unknown cell type.

Cases and controls were comparable in most demographic characteristics (Table 7). For both groups, the mean year of birth was 1917, the average age at hire was 36, and the mean length of employment at Delco Electronics was 14 years.

Although the 11 cases and 44 controls worked in 27 job categories, there were only 3 job categories in which 3 or more cases worked: machining operations, maintenance and general office. The odds ratio (OR), an estimated risk of dying from brain cancer, was calculated only for these three job categories, since an analysis with less than 3 cases would be meaningless. The odds ratio was elevated for machinists (OR=1.4), maintenance workers (OR=3.0) and general office personnel (OR=3.0) (Table 8). These increases, however, were not statistically significant.

B. Industrial Hygiene Summary

The use of solvents is limited and the quantities required at any one time was small. Working of beryllium metal was also extremely limited. The process is largely that of precision assembly and computerized testing.

The employment and process history of the plant is quite varied, on site processing of beryllium and the manufacture of component parts reportedly being discontinued and contracted out with the demise of the Apollo program and decline in Delco's production needs. Current production is about 95 completed units per month. Extensive environmental monitoring was reported during the 1960's but has declined with the elimination of an on-site industrial hygienist and reduction in production.

A review of the OSHA files going back to 1973 did not indicate any exposures to beryllium or solvents in excess of applicable OSHA standards. All but one of the values for beryllium were below the limits of detection of the analytical methods.

Potential workplace exposures during this investigation included beryllium deburred from gyroscopes, freon and trichloroethylene used in degreasing operations and halogenated aromatic hydrocarbons from the balancing fluid used in gyroscopic balancing operations.

VI. DISCUSSION

The request for a Health Hazard Evaluation which was sent to NIOSH indicated that 16 employees had died from brain tumors since the plant had opened. As described in an earlier NIOSH report,[1] it was confirmed that only 2 of these 16 employees actually died from brain malignancies. Clusters of brain tumors have been most recently observed in workers employed in the petrochemical and pharmaceutical industries (4-6). These workers are potentially exposed to aromatic hydrocarbons, solvents and other by-products of chemical manufacturing and refining.

None of the products identified at this plant are among the chemicals which have been demonstrated experimentally in animals to induce brain tumors.[8] The electronic components industry, as a whole, uses considerable amounts of solvents and degreasing agents, such as trichloroethylene, methylene chloride, 1,1,1-trichloroethane, toluene, and methyl ethyl ketone,[7] none of which have been shown to cause brain cancer in animals.

There is no clear explanation for the increase in brain cancer mortality among general office workers. Other studies of clerical workers did not

find increased mortality or morbidity from malignancies of the brain and central nervous system.[9-11] In addition, based on the work history of each case classified as a general office worker in our study, none held jobs as either machinists or maintenance workers. Although it is reasonable to conclude that machinists and maintenance workers could have had common exposures, we identified no obvious exposure which would also be experienced by office workers.

Although it might appear from the results of this investigation that employment in this plant as a machinist, maintenance or general office worker may be associated with an increased risk for brain cancer, we cannot conclude definitely whether the results are due to a real exposure or to chance. The PMR and PCMR analyses are limited to comparison of the proportion of brain cancer deaths only to the total known deaths in the study. The exclusion of the unknown deaths among the non-vested, terminated employees might have introduced some bias into the study, the magnitude of which depends upon the characteristics of those excluded.[2]. Additionally, the sample size in the case control study was very small.

We recommend that these results be used to generate hypotheses that could be tested in future epidemiologic research.

VII. REFERENCES

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IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Publications Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Confidential Requestors
2. United Auto Workers of America, Local 438
3. Delco Electronics Milwaukee Operations
4. United Auto Workers of America - International
5. General Motors Corporation
6. NIOSH, Region V
7. OSHA, Region V

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Table 1

DISTRIBUTION OF STUDY POPULATION

BY AGE AND YEAR OF DEATH

		1950-59	1960-69	1970-79	1980
LT*40	M	12	29	3	0
	F	10	3	1	0
40-49	M	14	32	16	2
	F	5	5	7	0
50-59	M	18	34	41	2
	F	1	15	10	1
60-69	M	6	36	71	6
	F	0	3	17	3
70-79	M	0	10	66	8
	F	0	0	8	3
GT*80	M	0	1	3	2
	F	0	0	0	0
TOTAL	M	50	142	200	20
	F	16	26	43	7

*LT = less than
GT = greater than

Table 2

CAUSE-SPECIFIC PROPORTIONATE MORTALITY RATIOS (PMR)
AMONG WHITE MALE EMPLOYEES BY PAY STATUS
(1950-1980)

CAUSE OF DEATH	HOURLY		SALARIED	
	O/E	PMR	O/E	PMR
All causes	235/235		177/177	
All malignant neoplasms	60/48.03	124	48/34.54	139
Buccal cavity & pharynx	3/1.54	194	2/1.10	182
Esophagus	1/1.12	89	3/0.76	395*
Stomach	2/2.28	88	0/1.60	---
Colon and rectum	6/4.02	149	4/4.02	100
Liver and biliary tract	1/1.13	88	2/0.79	253
Pancreas	6/2.63	228*	0/1.85	---
Respiratory System	15/16.29	92	11/11.37	97
Genitourinary system	7/5.56	126	7/3.94	178
Skin	2/0.92	217	4/0.79	506*
Brain	5/1.64	305*	4/1.35	296
Lymphosarcoma, reticulosarcoma	4/1.47	272	2/1.15	174
Other lymphatic and hematopoietic	4/3.40	118	7/2.71	258
Other malignant neoplasms	4/6.03	66	2/3.11	64
Diabetes Mellitus	4/3.34	120	2/2.53	79
Disorders of CNS	17/13.96	122	14/10.08	139
Diseases of Circulatory System	103/102.31	101	83/73.55	113
Nonmalignant Respiratory Diseases	8/13.20	61	8/9.34	86
Nephritis & Kidney Disease	0/1.97	---	4/1.59	251
Accidents	16/18.92	85	8/17.08	47
Homicide and Suicide	12/7.95	151	1/7.38	14
Other Causes	15/25.32	59	9/20.91	43

Note: *p is less than 0.05
O/E: Observed/Expected

Table 3

CAUSE-SPECIFIC PROPORTIONATE MORTALITY RATIOS (PMR)
AMONG WHITE FEMALE EMPLOYEES
(1950-1980)

CAUSE OF DEATH	O/E	PMR
All causes	92/92	
All malignant neoplasms (MN)	37/29.52	124
Stomach	4/0.79	506*
Colon and rectum	3/3.46	87
Liver and biliary tract	2/0.65	308
Lung and other respiratory organs	5/3.72	134
Breast	8/7.47	107
Ovary and fallopian tubes	6/2.44	246
Other genital organs	4/2.97	135
Brain	2/0.99	202
All lymphatic and hematopoietic	1/2.61	38
Other malignant neoplasms	2/4.42	45
Diabetes mellitus	1/2.08	48
Disorders of CNS	2/6.97	29
Diseases of Circulatory System	31/25.53	121
Nonmalignant respiratory disease	2/2.66	75
Accidents	4/5.61	71
Homocide and suicide	5/1.91	261
All other causes	10/17.72	56

Note: *p is less than 0.05
O/E: Observed/Expected

Table 4

CAUSE-SPECIFIC PROPORTIONATE CANCER MORTALITY RATIOS (PCMR)
AMONG WHITE MALE EMPLOYEES BY PAY STATUS
(1950-1980)

CAUSE OF DEATH	HOURLY		SALARIED	
	O/E	PCMR	O/E	PCMR
All malignant neoplasms	60/60		48/48	
Buccal cavity and pharynx	3/1.86	161	2/1.38	145
Esophagus	1/1.35	74	3/0.90	333
Stomach	2/2.77	72	0/2.04	---
Colon and rectum	6/7.25	82	4/5.26	76
Liver and biliary tract	1/1.40	71	2/1.00	200
Pancreas	6/3.28	183	0/2.35	---
Respiratory System	15/21.12	71	11/14.85	74
Other respiratory organs	2/1.15	174	0/0.83	---
Genital organs	2/4.20	48	3/3.18	94
Kidney	2/1.47	136	2/1.16	172
Bladder	3/1.76	170	2/1.06	189
Skin	2/1.15	174	4/1.49	268
Brain	5/1.94	258*	4/2.44	164
Connective tissue	2/0.26	769	0/0.33	---
Lymphosarcoma, reticulosarcoma	4/1.82	220	2/1.86	108
Hodgkins disease	1/0.85	117	2/1.74	115
Leukemia	1/2.45	41	4/2.74	146
Other lymphatic and hematopoietic malignancies	2/0.88	227	1/0.69	145
Other malignant neoplasms	3/4.19	71	2/3.53	57

Note: *p is less than 0.05
O/E: Observed/Expected

Table 5

CAUSE-SPECIFIC PROPORTIONATE CANCER MORTALITY RATIOS (PCMR)
AMONG WHITE FEMALE EMPLOYEES
(1950-1980)

CAUSE OF DEATH	O/E	PMR
All malignant neoplasms	37/37	
Stomach	4/1.03	388*
Colon and rectum	3/4.59	65
Liver and biliary tract	2/0.88	227
Lung and respiratory organs	5/4.11	122
Breast	8/8.97	89
Ovary and fallopian tubes	6/3.05	196
Other genital organs	4/3.54	113
Brain	2/1.25	160
Lymphatic & hematopoietic	2/3.20	63
Other malignant neoplasms	1/6.38	16

Note: *p is less than 0.05
O/E: Observed/Expected

Table 6

DIAGNOSIS FOR CASES CLASSIFIED AS BRAIN CANCERS

(1950-1980)

YEAR OF DEATH	AGE AT DEATH	DIAGNOSIS	(SEX)	SOURCE OF FINAL DIAGNOSIS	ICD
1959	57	Astrocytoma, Glade III	(M)	Pathology report	193.0
1959	50	Malignant tumor of brain	(M)	Death certificate	193.0
1960	20	Pinealoma	(F)	Pathology report	193.0
1963	38	Neurilemmoma VII cranial nerve	(M)	Autopsy report	193.0
1971	66	Glioblastoma multiforme (Astrocytoma, Grade III)	(M)	Autopsy report	191.0
1975	43	Cerebral carcinoma	(M)	Death certificate	191.0
1976	46	Thalamic glioblastoma multiforme	(M)	Pathology report	191.0
1976	72	Glioblastoma multiforme	(M)	Pathology report	191.0
1976	64	Glioblastoma multiforme	(F)	Pathology report	191.0
1978	59	Glioblastoma multiforme	(M)	Pathology report	192.9
1979	54	Glioblastoma multiforme	(M)	Pathology report	192.9

Table 7

COMPARISON OF CASES AND CONTROLS

	CASES	CONTROLS
- Mean year of birth	1917	1917
- Mean year first employed	1954	1953
- Mean age at hire	36 yrs.	36 yrs.
- Mean year last employed	1967	1967
- Mean age at termination	50 yrs.	50 yrs.
- Mean length of employment	14 yrs.	14 yrs.
- Total number	11	44

Table 8

ODDS RATIOS (OR) FOR MATCHED ANALYSIS OF BRAIN TUMORS
IN MACHINE OPERATORS, MAINTENANCE AND GENERAL OFFICE WORKERS

	CASES		CONTROLS			
	# EXPOSED	# UNEXPOSED	# EXPOSED	# UNEXPOSED	OR	CONFIDENCE LIMITS (95%)
Machinists	5	6	16	28	1.40	0.38 - 5.50
Maintenance	3	8	6	38	3.00	0.48 - 18.69
General office	4	7	8	36	3.00	0.60 - 15.09

DEPARTMENT OF HEALTH AND HUMAN SERVICES
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