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EPIDEMIOLOGIC FINDINGS  
DU PONT'S CAMDEN, S.C. SITE

Gentlemen:

On March 31, 1986, E. I. du Pont de Nemours and Company reported preliminary epidemiologic findings from a study of employees at its Camden, South Carolina site. This study has now been completed and a report prepared. The report is entitled:

EPIDEMIOLOGICAL STUDY ON WORKERS EXPOSED TO  
DIMETHYLFORMAMIDE AND/OR ACRYLONITRILE

A copy of this report is attached as promised in our letter of March 31, 1986.

Very truly yours,

Gerald A. Hapka

GAH/5/paa  
Att.  
8EHQ598DMF

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EPIDEMIOLOGICAL STUDY ON WORKERS EXPOSED TO  
DIMETHYLFORMAMIDE AND/OR ACRYLONITRILE

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### ABSTRACT

The objective of this study was to determine whether male employees with a history of exposure to dimethylformamide (DMF) alone or DMF and acrylonitrile (ACN) at the May Plant in Camden, South Carolina, experienced higher mortality or cancer incidence than expected.

A total of 5005 male employees were studied; 2530 of them were exposed to DMF but not ACN (DMF-only cohort), 1,329 were exposed to DMF and ACN (DMF/ACN cohort), 16 were exposed to ACN but not DMF (ACN-only cohort), and 1130 had no exposure to either DMF or ACN (non-exposed cohort). They were followed from 1956 through 1984 for cancer incidence and from 1950 through 1982 for mortality. The observed numbers of deaths by cause, and cancer cases by site, in each cohort were compared with the numbers expected based on Du Pont and U.S. mortality and cancer incidence rates adjusting for age and time period.

In every cohort, overall cancer incidence was not significantly different from expected based on either Du Pont or U.S. statistics. However, in the DMF-only cohort significant excesses were observed for buccal cavity/pharynx cancer, and malignant melanoma. A significant excess of prostate cancer was observed in the DMF/ACN cohort but not in the DMF-only cohort.

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Significant excess in total deaths, attributable mainly to ischemic heart disease and/or external causes, occurred among wage employees in every cohort when compared with Du Pont rates. However, there were no significant excesses in mortality when expected numbers were based on U.S. or South Carolina statistics.

No dose-response relationships were observed between DMF or ACN exposure and cancer incidence/mortality. The significant excesses in cancer incidence and mortality among employees exposed to DMF and/or ACN could be due to statistical chance or other factors such as tobacco and alcohol consumption.

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## INTRODUCTION

A previous epidemiological study of acrylonitrile workers at the May Plant reported an increased incidence of respiratory cancer (O'Berg, 1980). Because many employees of the ACN cohort were also exposed to DMF, it was unknown whether the excess in cancer incidence was restricted entirely to ACN workers, DMF workers, or workers exposed to both materials.

The initial objective of the present study was to determine if exposure to DMF and ACN, separately or in combination, was associated with higher than expected mortality or cancer incidence. However, since only 16 employees were exposed to ACN and never to DMF, the study's objective was revised to assess the effects of DMF alone or in conjunction with ACN on mortality or cancer incidence.

DMF has slight acute oral toxicity. It is capable of producing cumulative systemic toxicity when repeatedly absorbed through the skin or inhaled in sufficient quantities. Symptoms of over-exposure to DMF vapor include nausea and abdominal cramps or pains due to irritation of the upper digestive tract. Exposure to DMF followed by ingestion of alcoholic beverages may produce a reddening of the face and upper body.

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In animal studies, the liver has been shown to be a target organ for DMF through skin contact or inhalation. DMF has not been shown to be mutagenic or carcinogenic.

## METHODS

### A. Study Design and Cohort Definition

This study was of the historical cohort design. Five cohorts were defined through a review of all work history records at the plant:

#### (1) DMF-only Cohort

The DMF-only cohort consists of employees with potential exposure to DMF between 1950 and 1970 but with no exposure to ACN.

#### (2) ACN-only Cohort

The ACN-only cohort consists of employees with potential exposure to ACN between 1950 and 1966 but with no exposure to DMF.

#### (3) DMF/ACN Cohort

The DMF/ACN cohort consists of employees with potential exposure to both DMF and ACN.

(4) **Non-exposed Cohort**

The non-exposed cohort consists of employees who had no potential exposure to DMF and ACN.

(5) **All DMF cohort**

The DMF-only and DMF/ACN cohorts were combined to form the all DMF cohort.

**B. Exposure Classification**

No DMF exposure monitoring data were available for the period 1950-1970. Therefore an Exposure Classification Committee comprised of 15 employees was established to review the DMF exposure data and classify exposure levels. The potential exposure for each job was ranked according to amount of exposure (level) and frequency at which that amount of exposure was likely to occur. Three classifications were used to indicate relative level of exposure: high, moderate, low; and three categories were used to indicate frequency of exposure: frequent, intermittent, occasional. ACN exposure classifications had been reviewed by a separate committee in 1976 (O'Berg, 1980).

### C. Data Sources

Demographic and employment information, such as social security number, name, date of birth, sex, payclass (wage vs. salary), employment date, termination date, and job histories were obtained from work history records at the plant.

Cancer morbidity information for the cohorts was obtained from the Du Pont Cancer Registry. This registry was begun in 1956 and contains cancers diagnosed while individuals were employed at Du Pont. Details of the Du Pont Cancer Registry are described in a previous publication (Pell et al, 1978).

Information concerning deaths among active and pensioned employees of the cohorts was obtained from the Du Pont Mortality Registry. This registry was begun in 1957 and includes death information on all active employees and pensioners of Du Pont. Names of terminated employees were submitted to the Social Security Administration and National Death Index for determination of vital status, and year and place of death. Death certificates were obtained from state health departments. The underlying cause of death was coded by trained nosologists according to the revision of the International Classification of Diseases in effect at the time of death.

#### D. Analytical Methods

Mortality and cancer incidence were analyzed for the DMF-only cohort, for the DMF/ACN cohort, for both cohorts combined (all DMF cohort) and the non-exposed cohort. Within each cohort, wage and salary employees were studied separately. Wage employees, who are hourly paid, are generally operators and mechanics, and would have greater potential for chemical exposure. Salary employees are in clerical, supervisory, or management positions. Wage employees' chemical exposures, socioeconomics, and life-style (such as smoking, alcohol use) may be very different from salary employees. Therefore, their mortality and cancer incidence were evaluated separately.

Cancer incidence rates for the Du Pont Company (1956-1984) and the SEER (Surveillance, Epidemiology, End Results; National Cancer Institute) rates for the U.S. (1973-1977) were used to calculate expected numbers of cancer cases. Mortality rates for the Du Pont Company, U.S., and South Carolina were used to calculate expected numbers of deaths. Expected number calculations were performed by computer programs developed by Monson (1974) and by Marsh and Preininger (1980).

Cancer incidence from 1956 through 1984 and mortality from 1950 through 1982 were analyzed. Observed numbers of cancer cases or deaths were compared with the expected numbers based on

cases or deaths were compared with the expected numbers based on both Du Pont Company, U.S., and other available regional rates. Expected numbers were adjusted for age and time period by the indirect method of adjustment.

The expected numbers of cancer cases or deaths was computed by multiplying cause-, age-, sex-, and time-specific rates in the comparison population by the corresponding person-years distribution in the cohorts.

For analyses of cancer incidence, the number of person-years was calculated from the date of first exposure (or first employment) at the plant after January 1, 1956, through the earliest of the following events: the date of cancer diagnosis (or death), termination date, or December 31, 1984.

For mortality analyses, the number of person-years was calculated from the date of first exposure (or first employment) until the earliest of the following events: date of death, date lost to follow-up, or December 31, 1982.

Dose-response relationships for certain cancers were examined by exposure level and duration of exposure. In analyses of exposure levels, persons who had had the highest level of exposure were separated from all others. Duration of exposure was grouped into less than 5 years and 5 years or more. Latency

since first exposure was analyzed using periods of <15, 15-20, and 20+ years. Du Pont rates were used in calculating the expected numbers for these analyses.

Statistical significance tests of the difference between an observed and expected number were based on the Poisson probability distribution. The difference was considered to be statistically significant if the two-tailed probability was less than 0.05.

## RESULTS

The numbers of male employees by cohort and payclass are shown in Table 1. Females were excluded from analyses because of the small numbers. Since there were only 16 employees exposed to ACN but not to DMF, no further analyses were done on this subgroup.

### DMF-Only Cohort

The DMF-only cohort includes 2530 employees. Through a search of the Du Pont Cancer Registry from 1956 through 1984, 47 cases of cancer were identified in this cohort. The 47 cancer cases include 9 buccal cavity and pharynx, 11 lung, 5 malignant melanoma, 4 prostate, 3 stomach, 2 intestine, 3 nervous system, 4 lymphohematopoietic system, 2 bladder, and 1 each of kidney, testis, thyroid, and mediastinum.

The observed numbers of cancer cases in the DMF-only cohort were compared with the expected numbers based on Du Pont rates (Table 2) and U.S. SEER rates (Table 3). Except for buccal cavity and pharynx cancer, the observed numbers for all cancers and individual cancer sites in this cohort were not significantly higher than the expected based on Du Pont rates. Nine cases of buccal cavity and pharynx cancer were significantly higher than

1.6 expected based on Du Pont rates and 3.3 expected based on U.S. SEER rates. Eight out of nine buccal cavity and pharynx cancer cases were among wage employees.

Five cases of malignant melanoma among wage employees were significantly higher than 1.6 expected based on U.S. rates, but not significantly higher than 2.1 expected based on Du Pont rates. All 5 cases of malignant melanoma fell into the high DMF exposure category.

With respect to mortality in the DMF-only cohort, there were 225 deaths between 1960 and 1982. The observed numbers of all causes, ischemic heart disease, digestive system diseases, and external causes were significantly higher than expected among the wage employees, based on Du Pont rates (Table 4). However, there were no significant excesses for these causes based on U.S. (Table 5) or South Carolina statistics. The mortality rates of all causes, ischemic heart disease, and external causes for South Carolina are higher than those for U.S. For overall cancer mortality from all cancers or from individual cancer sites, no significant excesses were observed for comparisons based on either Du Pont or U.S. experience.

Because of the significant excess in buccal cavity and pharynx cancer incidence in this cohort, further analyses were done for this cancer. A detailed listing of the 9 cases is

presented in Table 6. Six cases were exposed to DMF at high levels, and three at moderate levels. For histological types, 8 were squamous cell carcinomas and one was adenocystic carcinoma. Four cases were lip cancer, 2 oral cavity (1 mouth and 1 tongue) and 3 pharynx cancer. The observed and expected numbers by anatomical site are shown in Table 7. Although the numbers are small, cancers of the lip and pharynx were significantly higher than the expected based on Du Pont rates.

#### Non-exposed Cohort

Cancer incidence of the non-exposed cohort revealed no significant excesses (Table 8). For mortality, all causes in wage employees and external causes in salary and all male employees showed significant excesses when compared with Du Pont statistics, but no significant excesses were shown when compared with U.S. (Tables 9 and 10).

#### DMF/ACN Cohort

With the exception of prostate cancer, employees exposed to DMF and ACN showed no significant excesses for all cancers and for individual cancer sites. There were 6 prostate cancer cases in this cohort with 2.3 expected based on Du Pont rates and 2.1 expected based on U.S. SEER rates (Tables 11 and 12). No dose-response patterns to DMF or ACN were observed. As shown in

Tables 13 and 14, deaths from all causes and ischemic heart disease among wage employees in DMF/ACN cohort were significantly greater than expected based on Du Pont rates. There were no significant excesses when expected numbers were based on U.S. or South Carolina statistics. No site-specific cancer deaths were significantly in excess, irrespective of which population was used for comparison.

#### All DMF Cohort

The results for all employees with potential exposure to DMF are shown in Tables 15-18. This cohort is a combination of the DMF-only and DMF/ACN cohorts (3859 employees total). The 11 cases of buccal cavity and pharynx cancer in this cohort were significantly higher than the 3.2 expected based on Du Pont rates, but not significantly higher than the 6.6 expected based on U.S. rates. No significant excess in incidence was observed for other cancer sites.

Similar to the mortality results for DMF-only cohort, the elevations for all causes, ischemic heart disease, and external causes were statistically significant when compared with Du Pont's experience, but not statistically significant when compared with U.S. or South Carolina statistics.

When the 11 cancer cases of buccal cavity and pharynx were analyzed by DMF exposure level (Table 19) and DMF exposure duration (Table 20), no dose-response relationships were observed.

## DISCUSSION

### Buccal Cavity and Pharynx Cancer

This study is the first epidemiological study investigating if there is a relationship of DMF exposure on mortality and cancer incidence. The significant excess in the incidence of buccal cavity and pharynx cancer among employees exposed to DMF was observed in the DMF-only cohort, but not in the DMF/ACN cohort. There are several hypotheses for this finding. First, the excess could be due to statistical chance. When many comparisons are made, the chance of finding significance is high, even in the absence of any causal association. Second, the DMF-only cohort may have been exposed to DMF at higher levels than the DMF/ACN cohort. However, the risk of developing buccal cavity and pharynx cancer did not appear to increase with DMF exposure level. Third, the DMF-only cohort may have been exposed to DMF longer than the DMF/ACN cohort. However, this study found that the risk of developing buccal cavity and pharynx cancer was not associated with duration of exposure. Fourth, confounding factors (such as tobacco or alcohol consumption) for buccal cavity and pharynx cancer may have played a greater role in one cohort than another.

Other studies have found that risk of developing buccal cavity and pharynx cancer was associated with cigarette, cigar, and pipe smoking, chewing tobacco, use of snuff, and alcohol drinking. Information on these factors was not obtained for every employee in this study. We found that all 11 cancer cases of buccal cavity and pharynx were heavy smokers for a long duration (at least 20 years) and two of them were heavy drinkers. Information on chewing tobacco or use of snuff was not ascertained.

Occupational/chemical exposures have not been regarded as important risk factors for buccal cavity and pharynx cancers, although some studies have raised this possibility. A group of textile workers studied by Moss and Lee (1974) appeared to have a higher risk of developing buccal cavity and pharynx cancer, but no specific chemicals were studied.

Although incidence was elevated, mortality from buccal cavity and pharynx cancer showed no significant excess, possibly because the survival rate for this cancer site generally is high. The 5-year survival rate for lip cancer is 90 percent, for salivary gland 70 percent, mouth and tongue 50 percent and pharynx 15 percent (Mahboubi and Sayed, 1982).

### Malignant Melanoma

The number of malignant melanoma cases among the wage employees in the DMF-only cohort was significantly higher than expected when compared to U.S. rates, but not significantly higher when compared with Du Pont statistics. The incidence rates of malignant melanoma in the Du Pont Company are higher than the SEER rates for the U.S., possibly because the majority of Du Pont's plants are located in the South where the incidence of malignant melanoma is high. There are no cancer incidence rates available for South Carolina. The available adjacent local rates for comparison are SEER rates at Atlanta; no significant excess of malignant melanoma is seen when Atlanta SEER rates are used to calculate expected numbers.

### Prostate Cancer

Excesses of prostate cancer incidence among ACN workers were reported earlier in two independent studies at Du Pont (Chen, 1985; O'Berg et al, 1985). The wage roll employees of the DMF/ACN cohort showed a significant elevation in prostate cancer incidence when compared with U.S. rates. However, since this phenomenon is not observed in the DMF-only cohort, the significant elevation was unlikely to be due to DMF exposure. This study found that the risk of developing prostate cancer was not higher among employees exposed to higher levels of DMF or

ACN, or with longer duration of exposure to DMF or ACN, than those with low exposure levels or shorter exposure duration to either chemical. The number of prostate cancer cases was too small to detect the interaction of DMF and ACN or other chemicals. The significant excess may be due to statistical chance or confounded by other factors, such as ethnicity, life-style, etc.

#### Non-cancer Mortality

For every cohort in this study, there were no significant excesses in mortality for any cause of death when compared with U.S., South Carolina or surrounding counties mortality statistics. However, when compared to Du Pont, some causes of death showed significant excesses in some cohorts. These excesses occurred primarily among wage roll employees and reflected excesses in the ischemic heart disease and external causes categories. The majority of external cause deaths was due to motor vehicle accidents.

We found no dose-response relationship between DMF or ACN exposure with the mortality of all causes, ischemic heart disease and external causes. Moreover, the non-exposed group has significant excesses in all causes of death among wage roll employees and in external causes among all employees. Therefore,

we believe that the significant excesses of all causes, ischemic heart disease and external causes in the DMF cohort were due to factors other than DMF or ACN exposure.

Since South Carolina has higher mortality rates of ischemic heart disease and external causes than the U.S, regional and life-style factors might play very important roles in these two causes.

#### Summary

Statistically significant excesses of buccal cavity/pharynx cancer and of malignant melanoma incidence were observed in the DMF-only cohort. A statistically significant excess of prostate cancer incidence was observed in the DMF/ACN cohort. Examinations of these excesses showed no relationships between DMF or ACN exposure levels, exposure duration, and cancer risk. The excesses could be due to certain life-style factors such as alcohol, tobacco consumption, sunlight exposure, etc.

Significant mortality excesses were observed for ischemic heart disease and external causes. Because the majority of external cause deaths was due to motor vehicle accidents and since South Carolina has higher mortality rates of both ischemic heart disease and external causes than the U.S., these excesses are thought to be unrelated to DMF or ACN exposure.

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Table 1

**Numbers of Male Employees by Cohort  
and Payclass**

	<u>Male Wage</u>	<u>Male Salary</u>	<u>Total</u>
<b>DMF Only</b>	<b>1856</b>	<b>674</b>	<b>2530</b>
<b>DMF/ACN</b>	<b>1185</b>	<b>144</b>	<b>1329</b>
<b>ACN Only</b>	<b>8</b>	<b>8</b>	<b>16</b>
<b>Non-Exposed</b>	<b>692</b>	<b>438</b>	<b>1130</b>
<b>TOTAL</b>	<b>3741</b>	<b>1264</b>	<b>5005</b>

Table 2

Observed and Expected Numbers of Cancer Cases, 1956-1984

DMF Only Cohort

Based on Du Pont Company Rates

	<u>WAGE</u>		<u>SALARY</u>		<u>TOTAL</u>	
	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>
All Cancers	34	25.3	13	14.7	47	40.0
Buccal Cavity & Pharynx	8	1.0**	1	0.6	9	1.6**
Lung	7	5.5	4	2.8	11	8.3
Malignant Melanoma	5	2.1	0	1.3	5	3.4
Prostate	1	1.5	3	0.9	4	2.4
Stomach	2	0.5	1	0.3	3	0.8
Intestine	2	2.4	0	1.9	2	4.3
Nervous System	2	1.0	1	0.5	3	1.5
All Lympho- hematopoietic	4	3.3	0	1.8	4	5.1
Bladder	1	1.3	1	0.7	2	2.0
All Other	2	6.7-	2	3.9	4	10.6-

\*\* Significantly greater than expected,  $p < 0.01$  (2-tailed).

- Significantly less than expected,  $p < 0.05$  (2-tailed).

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Table 3

Observed and Expected Numbers of Selected Cancers, 1956-1984,

DMF Only Cohort

Based on SEER Rates for U.S. Males, 1973-77

	<u>WAGE</u>		<u>SALARY</u>		<u>TOTAL</u>	
	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>
All Sites	34	29.3	13	19.2	47	48.5
Buccal Cavity & Pharynx	8	2.0**	1	1.3	9	3.3*
Lung	7	6.2	4	4.5	11	10.7
Malignant Melanoma	5	1.6*	0	0.8	5	2.4
Prostate	1	1.3	3	1.2	4	2.5

\* Significantly greater than expected,  $p < 0.05$  (2-tailed).

\*\* Significantly greater than expected,  $p < 0.01$  (2-tailed).

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Table 4

Observed and Expected Numbers of Selected Major Causes of Death,  
1950-1982, DMF Only Cohort  
Based on Du Pont Company Rates

	<u>WAGE</u>		<u>SALARY</u>		<u>TOTAL</u>	
	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>
All Causes	184	115.2**	41	45.0	225	160.2**
All Malignant Neoplasms	29	27.1	9	13.0	38	40.1
Ischemic Heart Disease	62	40.3**	15	17.0	77	57.3*
Cerebrovascular Disease	5	5.5	4	2.2	9	7.7
Diseases of Digestive System	8	3.4*	0	1.5	8	4.9
External Causes	44	23.9**	2	4.7	46	28.6**

\* Significantly greater than expected,  $p < 0.05$  (2-tailed).

\*\* Significantly greater than expected,  $p < 0.01$  (2-tailed).

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Table 5

Observed and Expected Numbers of Selected Major Causes of Death,  
1950-1982, DMF Only Cohort  
Based on U. S. White Male Rates

	<u>WAGE</u>		<u>SALARY</u>		<u>TOTAL</u>	
	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>
All Causes	184	174.8	41	81.6--	225	256.4
All Malignant Neoplasms	29	34.1	9	16.7-	38	50.8
Ischemic Heart Disease	62	48.6 <sup>0</sup>	15	25.3-	77	73.9
Cerebrovascular Disease	5	6.0	4	3.5	9	9.5
Diseases of Digestive System	8	11.0	0	4.8	8	15.8-
External Causes	44	40.9	2	14.6--	46	55.5

<sup>0</sup> p = 0.07 (2-tailed).

- Significantly less than expected, p < 0.05 (2-tailed).

-- Significantly less than expected, p < 0.01 (2-tailed).

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Table 6

List of Cancer Cases of Buccal Cavity and Pharynx  
1956-1984, DMF Only Cohort

Anatomic Site	Histologic Type <sup>1</sup>	Age Dx	Yr Dx	Yr. 1st Exp	Exp <sup>2</sup> Level	Exp Length (Yrs.)	Latency (Yrs.)
Mouth	Sq. Cell Carcinoma	58	82	50	H	9.3	32
Tongue	Sq. Cell Carcinoma	57	83	51	H	18.4	32
Lip	Sq. Cell Carcinoma	42	66	51	H	9.8	15
Lip	Sq. Cell Carcinoma	51	69	51	H	1.8	18
Lip	Sq. Cell Carcinoma	58	81	52	H	<0.1	29
Lip	Adenocystic Carcinoma	46	79	68	H	0.4	11
Tonsil (Oropharynx)	Sq. Cell Carcinoma	60	76	52	M	18.4	24
Nasopharynx	Sq. Cell Carcinoma	33	68	67	M	0.6	1
Hypopharynx	Sq. Cell Carcinoma	57	82	63	M	7.7	19

<sup>1</sup> Sq. cell carcinoma - Squamous cell carcinoma

<sup>2</sup> H - High; M - Moderate

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Table 7

Observed and Expected Numbers of  
Buccal Cavity and Pharynx Cancer Cases  
by Anatomical Site  
DMF-Only Cohort  
Based on Du Pont Company Rates

	<u>WAGE</u>		<u>SALARY</u>		<u>TOTAL</u>	
	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>
Lip	4	0.27**	0	0.06	4	0.33**
Oral Cavity (Palate/ Mouth/Tongue)	2	0.27 <sup>†</sup>	0	0.22	2	0.49
Pharynx	2	0.28 <sup>†</sup>	1	0.12	3	0.40*

<sup>†</sup> p = 0.06 (2-tailed).

\*\* Significantly greater than expected, p < 0.01 (2-tailed).

\* Significantly greater than expected, p < 0.05 (2-tailed).

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Table 8

Observed and Expected Numbers of Selected Cancer Cases,  
1956-1984, Non-Exposed Cohort  
Based on Du Pont Company Rates

	<u>WAGE</u>		<u>SALARY</u>		<u>TOTAL</u>	
	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>
All Cancers	5	5.1	12	10.8	17	15.9
Buccal Cavity & Pharynx	0	0.2	1	0.4	1	0.6
Lung	2	0.9	2	2.0	4	2.9
Malignant Melanoma	2	0.6	2	0.9	4	1.5
Thyroid Gland	0	0.1	2	0.1	2	0.2
All other	1	3.3	5	7.4	6	10.7

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Table 9

Observed and Expected Numbers of Selected Major Causes of Death,  
1950-1982, Non-Exposed Cohort  
Based on Du Pont Company Rates

	<u>WAGE</u>		<u>SALARY</u>		<u>TOTAL</u>	
	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>
All Causes	43	26.9**	35	34.6	78	61.5
All Malignant Neoplasms	7	5.6	8	9.6	15	15.2
Ischemic Heart Disease	11	8.2	8	13.3	19	21.5
External Causes	14	7.7 <sup>†</sup>	10	3.4**	24	11.1**

\*\* Significantly greater than expected,  $p < 0.01$  (2-tailed).

<sup>†</sup>  $p = 0.052$  (2-tailed).

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Table 10

Observed and Expected Numbers of Selected Major Causes of Death,  
1950-1982, Non-Exposed Cohort  
Based on U. S. White Male Rates

	<u>WAGE</u>		<u>SALARY</u>		<u>TOTAL</u>	
	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>
All Causes	43	40.9	35	60.6--	78	101.5-
All Malignant Neoplasms	7	7.1	8	12.4	15	19.5
Ischemic Heart Disease	11	9.7	8	19.1-	19	28.8-
External Causes	14	12.7	10	10.3	24	23.0

- Significantly less than expected,  $p < 0.05$  (2-tailed).

-- Significantly less than expected,  $p < 0.01$  (2-tailed).

00035

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Table 11

Observed and Expected Numbers of Cancer Cases, 1956-1984,

DMF/ACN Cohort

Based on Du Pont Company Rates

	<u>WAGE</u>		<u>SALARY</u>		<u>TOTAL</u>	
	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>
All Cancers	36	33.5	5	6.3	41	39.8
Buccal Cavity & Pharynx	1	1.4	1	0.2	2	1.6
Digestive	4	7.4	1	1.6	5	9.0
Lung	10	8.1	0	1.3	10	9.4
Malignant Melanoma	2	2.2	0	0.5	2	2.7
Bladder	1	1.8	2	0.3	3	2.1
Prostate	6	2.3 <sup>†</sup>	0	0.4	6	2.7
All Lymphatic	6	3.7	1	0.7	7	4.4
All Other	6	6.6	0	1.3	6	7.9

<sup>†</sup> p = 0.06 (2-tailed).

00036

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Table 12

Observed and Expected Numbers of Selected Cancers

1956-1984, DMF/ACN Cohort

Based on SEER Rates for U.S. Males, 1973-77

	<u>WAGE</u>		<u>SALARY</u>		<u>TOTAL</u>	
	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>
All Cancers	36	39.3	5	8.3	41	47.6
Buccal Cavity & Pharynx	1	2.7	1	0.6	2	3.3
Lung	10	9.0	0	2.0	10	11.0
Malignant Melanoma	2	1.8	0	0.3	2	2.1
Prostate	6	2.1*	0	0.6	6	2.7

\* Significantly greater than expected,  $p < 0.05$  (2-tailed).

00037

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Table 13

Observed and Expected Numbers of Selected Major Causes of Death,  
1950-1982, DMF/ACN Cohort  
Based on Du Pont Company Rates

	<u>WAGE</u>		<u>SALARY</u>		<u>TOTAL</u>	
	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>
All Causes	152	128.2*	16	16.5	168	144.7
All Malignant Neoplasms	33	31.6	4	4.7	37	36.3
Ischemic Heart Disease	65	48.3*	7	6.6	72	54.9*
Cerebrovascular Disease	3	6.8	1	0.8	4	6.6
Diseases of Digestive System	6	4.2	0	0.6	6	4.8
External Causes	25	19.1	2	1.4	27	20.5

\* Significantly greater than expected,  $p < 0.05$  (2-tailed).

00038

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Table 14

Observed and Expected Numbers of Selected Major Causes of Death,  
1950-1982, DMF/ACN Cohort  
Based on U. S. White Male Rates

	<u>WAGE</u>		<u>SALARY</u>		<u>TOTAL</u>	
	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>
All Causes	152	184.7-	16	28.5 --	168	213.2--
All Malignant Neoplasms	33	38.2	4	6.2	37	44.4
Ischemic Heart Disease	65	57.1	7	9.5	72	66.6
Cerebrovascular Disease	3	7.2	1	1.2	4	8.4
Diseases of Digestive System	6	11.6	0	1.7	6	13.3-
External Causes	25	33.1	2	3.9	27	37.0

- Significantly less than expected,  $p < 0.05$  (2-tailed).

-- Significantly less than expected,  $p < 0.01$  (2-tailed).

Table 15

**Observed and Expected Numbers of Selected Cancers,  
1956-1984, All DMF Cohort  
Based on Du Pont Company Rates**

	<u>WAGE</u>		<u>SALARY</u>		<u>TOTAL</u>	
	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>
All Cancers	70	58.8	18	21.0	88	79.8
Buccal Cavity & Pharynx	9	2.4**	2	0.8	11	3.2**
Lung	17	13.6	4	4.1	21	17.7
Malignant Melanoma	7	4.3	0	1.8	7	6.1
Prostate	7	3.8	3	1.3	10	5.1

\*\* Significantly greater than expected,  $p < 0.01$  (2-tailed).

00040

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Table 16

Observed and Expected Numbers of Selected Cancers

1956-1984, All DMF Cohort

Based on SEER Rates for U.S. Males, 1973-77

	<u>WAGE</u>		<u>SALARY</u>		<u>TOTAL</u>	
	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>
All Cancers	70	68.6	18	27.5-	88	96.1
Buccal Cavity & Pharynx	9	4.7	2	1.9	11	6.6
Lung	17	15.2	4	6.5	21	21.7
Malignant Melanoma	7	3.4	0	1.1	7	4.5
Prostate	7	3.4	3	1.8	10	5.2

- Significantly less than expected,  $p < 0.05$  (2-tailed).

Table 17

Observed and Expected Numbers of Selected Major Causes of Death,  
1950-1982, All DMF Cohort  
Based on Du Pont Company Rates

	<u>WAGE</u>		<u>SALARY</u>		<u>TOTAL</u>	
	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>
All Causes	336	243.4**	57	61.5	393	304.9**
All Malignant Neoplasms	62	58.7	13	17.7	75	76.4
Ischemic Heart Disease	127	88.6**	22	23.6	149	112.2**
Cerebrovascular Disease	8	12.3	5	3.0	13	15.3
Diseases of Digestive System	14	7.6*	0	2.1	14	9.7
External Causes	69	43.0**	4	6.1	73	49.1**

\* Significantly greater than expected,  $p < 0.05$  (2-tailed).

\*\* Significantly greater than expected,  $p < 0.01$  (2-tailed).

00042

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Table 18

Observed and Expected Numbers of Selected Major Causes of Death,  
1950-1982, All DMF Cohort  
Based on U. S. White Male Rates

	<u>WAGE</u>		<u>SALARY</u>		<u>TOTAL</u>	
	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>
All Causes	336	359.5	57	110.1--	393	469.6--
All Malignant Neoplasms	62	72.3	13	22.9-	75	95.2
Ischemic Heart Disease	127	105.7	22	34.8-	149	140.5
Cerebrovascular Disease	8	13.2	5	4.7	13	17.9
Diseases of Digestive System	14	22.6-	0	6.5--	14	29.1--
External Causes	69	74.0	4	18.5--	73	92.5-

- Significantly less than expected,  $p < 0.05$  (2-tailed).

-- Significantly less than expected,  $P < 0.$  (2-tailed).

00043

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Table 19

Observed and Expected Numbers of Cancer Cases  
of Buccal Cavity and Pharynx, 1956-1984,  
by DMF Exposure Level and Payclass  
All DMF Cohort  
Based on Du Pont Company Rates

	<u>DMF EXPOSURE LEVEL</u>					
	<u>HIGH</u>		<u>NOT HIGH</u>		<u>TOTAL</u>	
	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>
Wage	6	1.8*	3	0.6*	9	2.4**
Salary	0	0.2	2	0.6	2	0.8
Total	6	2.0*	5	1.2*	11	3.2**

\* Significantly greater than expected,  $p < 0.05$  (2-tailed).

\*\* Significantly greater than expected,  $p < 0.01$  (2-tailed).

00044

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Table 20

Observed and Expected Numbers of Cancer Cases  
of Buccal Cavity and Pharynx, 1956-1984,  
By Duration of Exposure,  
All DMF Cohort, All Males  
Based on Du Pont Company Rates

<u>Latency</u>	<u>Duration of Exposure</u>					
	<u>&lt; 5 Yrs.</u>		<u>5+ Yrs.</u>		<u>Total</u>	
	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>	<u>OBS</u>	<u>EXP</u>
15 Yrs.	2	0.5	0	0.4	2	0.9
15-20 Yrs.	1	0.2	2	0.4	3	0.6*
20+ Yrs.	1	0.4	5	1.4*	6	1.8*
Total	4	1.1 <sup>†</sup>	7	2.2*	11	3.3**

<sup>†</sup> P = 0.052 (2-tailed).

\* Significantly greater than expected, p < 0.05 (2-tailed).

\*\* Significantly greater than expected, p < 0.01 (2-tailed).

00045

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