

A PROPORTIONAL MORTALITY STUDY
OF MONSANTO-INDIAN ORCHARD PLANT EMPLOYEES

SUMMARY

In a proportional mortality analysis of 564 deceased Monsanto-Indian Orchard plant workers, no statistically significant excess was seen in the overall number of deaths due to cancer or in the number of deaths from any specific cancer site, including cancer of the pancreas. There is no suggestion of an increased proportion of cancer deaths when analyzed site-specifically by age at death, year of death, or by the number of years since started working. An analysis of cancer deaths by place of birth revealed an excess of prostate cancer among the U. S. born, but not among the foreign born. This differential by place of birth has not been explained. No statistically significant excess was seen in any of several non-malignant cause of death categories, with the exception of arteriosclerotic heart disease.

BACKGROUND

In 1975, a Massachusetts activist group and a Massachusetts State Occupational Hygiene Physician reported that their examination of 86 death certificates indicated an overall excess of cancer and an excess of cancer of the pancreas among former Monsanto-Indian Orchard plant workers. In response to these concerns, Monsanto provided additional mortality data to the National Institute for Occupational Safety and Health, and independently initiated a proportional mortality epidemiology study to determine if there was an increased proportion of deaths from all cancers or from cancer of the pancreas, and if there was an increased proportion of deaths from any of the major non-malignant causes of death.

METHODOLOGY

Selected for study were the 564 deaths observed from 1950 through 1976 among workers and former workers of the Monsanto-Indian Orchard plant. The decedents were identified mainly from personnel and medical benefits records and are basically comprised of persons who died while they were active employees and of pensioned employees who are known to have died. The death certificates of females and non-white males were excluded from analysis because of their relatively small number of deaths.

All deaths were confirmed by death certificate. Information on underlying cause of death was coded from the death certificate by an independent trained nosologist to the Seventh Revision of the International Classification of Diseases, Adapted.¹

The data were analyzed by the proportional mortality method, whereby the observed number of deaths is compared to an expected number of deaths based on standard population. For each cause of death, a proportional mortality ratio was calculated as the ratio of the number of observed deaths to the number of expected deaths. Proportional mortality ratios were calculated for fourteen cancer categories by age at death, year of death, number of years since started working, and place of birth.

Proportional mortality analyses were carried out using the age groupings: 20-29, 30-39, 40-49, 50-59, 60-69, 70-79, and 80+. The expected number of deaths was calculated based on mortality data from the Vital Statistics of the United States²⁻⁴ according to the formula:

$$\sum_p \text{Expected}_k = \sum_p \sum_j T_{jk} \frac{s_{jk}}{S_j}$$

Where T_{jk} = number of observed deaths from all causes in the j th age group of the study population.

s_{jk} = number of deaths from cause k in the j th age group of the standard population!

S_j = number of deaths from all causes in the j th age group of the standard population.

p = time interval.

Where U. S. death rates were coded to the Eighth Revision of the I.C.D.⁵ conversion was made to the Seventh Revision using comparability ratios. For each cause of death, an expected number of deaths was calculated over three time periods: 1950-1959, 1960-1969, 1970-1976, using mortality data from 1955, 1965, and 1973, respectively.

For cancer deaths, the expected numbers based on U. S. rates were adjusted for the local cancer mortality rate using data from U. S. Cancer Mortality by County: 1950-1969.⁶ The expected numbers were adjusted, site-specifically, according to the ratio of the Hampden County mortality rate to the U. S. mortality rate. The adjustment factors are given in Appendix A. It should be noted that the expected numbers for the sub-cancer categories will not add to the total expected numbers for the main cancer categories because of weighting factors.

Mortality data on non-malignant causes of death are not generally available by county. The expected numbers for the non-cancer deaths are based only on U. S. rates. The total number of observed deaths will not equal the total number of expected deaths because the cancer cause of death categories have been adjusted for the local death rate.

A chi-square statistic was calculated for the observed and expected number of deaths where there were at least five expected and observed cases. Tests of significance using binomial probabilities were calculated where the number of expected or observed cases was less than five. All tests were made at the 5% level of significance. Tests of significance for the overall cancer and pancreatic cancer categories are actually the only valid comparisons that can be made. Tests of significance for the other cause of death categories were carried out realizing that the probability of a comparison showing significance by chance alone increases with the number of comparisons made. With n comparisons, the probability of being wrong in one or more comparisons is $1 - (.95)^n$.

RESULTS

No statistically significant excess was seen in the overall number of cancer deaths with 118 observed and 116.75 expected (Table I). No increase was seen in deaths from pancreatic cancer with 6 observed and 6.89 expected. No significant increase was seen in any of the other cancer mortality sites.

With the exception of deaths from arteriosclerotic heart disease (237 observed with 203.23 expected), there is no suggestion of an increased proportion of deaths from any of several non-malignant causes of death.

The analysis of cancer deaths by age at death (Table II), year of death (Table III), and the number of years since started working (Table IV) did not reveal any consistent trends that would indicate a positive association between employment and excess cancer mortality. In studying a relatively stable working population as we are here, one would look for increasing proportional mortality ratios, with increasing age at death, with more recent years of death, or with longer lengths of time since started working, as an indication of an occupational carcinogen operating on the mortality experience of workers.

An analysis by birthplace was also carried out revealing a statistically significant excess of prostate cancer in the U. S. born. There were 9 cases of prostate cancer with 4.59 expected. There was no excess among the foreign born with 3 observed deaths and 3.67 expected.

DISCUSSION

When studying cancer, the most representative rates to use in computing expected mortality are usually the mortality rates for the local population in the area in which the plant is located. The Indian Orchard plant is located in Hampden County, Massachusetts. Cancer mortality data are available on an age-adjusted site-specific basis for the period 1950-1969. There are some circumstances which might not favor the use of county mortality data. These include: 1) a large percentage of the county population may be employed in the plant under study, and 2) the county may have an unusually high concentration of related heavy industry and the industrial emissions could adversely affect the health experience of the surrounding community. However, these factors are not applicable to the present study in which data from Hampden County are used to assess the mortality experience of Indian Orchard plant employees.

Based on Hampden County data, the proportional mortality ratios do not show any consistent trends that would indicate an increased proportion of deaths from all cancers, pancreatic cancer, or from any site-specific cancer, with the exception of prostate cancer in the U. S. born. A review of the work histories of the prostate cancer cases was made to determine if there was any commonality in occupational exposures among the U. S. born that could account for the differential in prostate cancer by birthplace. The results of the work history analysis is detailed in Appendix B. There does not appear to be any departmental

clustering that could explain the excess. However, no further conclusions can be drawn because the small numbers of cases scattered over several departments will not permit a valid case-control analysis.

An excess was also seen in the number of deaths from arteriosclerotic heart disease, with 237 observed deaths and 203.23 expected. There was no overall excess in the number of deaths from cardiovascular disease with 318 observed and 307.23 expected, so that the excess in deaths from arteriosclerotic heart disease may be due to a deficiency of deaths from other cardiovascular disease.

The proportional mortality method used here to screen for occupationally related diseases did not reveal any increased proportions in deaths that could be directly linked to occupational factors.

REFERENCES

1. National Center for Health Statistics: Seventh Revision International Classification of Diseases Adapted for Use in the United States. Vol. 1, Tabular List; and Vol. 2, Alphabetical Index. 1957.
2. Vital Statistics of the United States 1955, Volume II - Mortality Data, HEW Public Health Service, Washington, 1957.
3. Vital Statistics of the United States 1965, Volume II - Mortality, Part A, HEW Public Health Service, Washington, 1967.
4. Vital Statistics of the United States 1973, Volume II - Mortality, Part A, DHEW Pub. No. (HRA) 77-1101.
5. Mortality Trends for Leading Causes of Death: United States - 1950-69, DHEW Pub. No. (HRA) 74-1853.
6. Mason TJ, et al: U.S. Cancer Mortality by County: 1950-1969, DHEW Pub. No. (NIH) 74-615.

Table I

Observed and Expected Deaths, 1950-1976

Death with I.C.D. No. (Seventh Revision)	Observed	Expected†	P.M.R.
Neoplasms (001-019)	0	3.73	--
Neoplasms (140-205)	118	116.75	1.01
Oral cavity and pharynx (140-148)	3	4.43	.68
Digestive organs and peritoneum (150-156A, 157-159)	46	39.20	1.17
Biliary passages and liver (155)	3	1.51	1.99
Esophagus (157)	6	6.89	.87
All other digestive organs (Residual)	37	31.07	1.19
Respiratory system (160-164)	24	33.34	.72
Genital organs (177-179)	14	8.78	1.59
Prostate (177)	12	8.27	1.45
All other genital organs (Residual)	2	0.45	4.44
Urinary organs (180-181)	7	6.69	1.05
Other and unspecified sites (Residual)	15	11.89	1.26
Leukemia and aleukemia (204)	2	4.10	.49
Lymphomas (200-203, 205)	7	6.70	1.04
Diabetes mellitus (260)	9	7.99	1.13
Diseases of cardiovascular system (330-334, 400-468)	318	307.53	1.03
Vascular lesions affecting CNS (330-334)	41	44.07	.93
Rheumatic heart disease (400-402, 410-416)	5	5.57	.90
Arteriosclerotic heart disease (420)	237	203.23	1.17*
Rheumatic chronic endocarditis (421-422)	6	8.79	.68
Other diseases of heart (430-434)	6	10.41	.58
Hypertensive heart disease (440-443)	5	10.98	.46*
Other hypertensive disease (444-447)	3	2.40	1.25
General arteriosclerosis (450)	8	5.99	1.34
Other diseases of circulatory system (451-468)	7	7.52	.93
Influenza and pneumonia (480-493)	14	13.00	1.08
Perforation of stomach and duodenum (540-541)	2	4.53	.44
Appendicitis (550-553)	2	.57	3.51
Intestinal obstruction (560-561, 570)	2	2.11	.95
Gastritis, duodenitis, enteritis, and colitis (543, 571-572)	3	1.07	2.80
Cirrhosis of liver (581)	9	13.14	.68
Nephritis and nephrosis (590-594)	5	3.67	1.36
Hyperplasia of prostate (610)	1	1.40	.71
Coma, senility, and ill-defined conditions	2	6.19	.32
Motor vehicle accidents (E810-E835)	10	16.14	.62
Other accidents (E800-E802, E840-E962)	16	18.53	.86
Poisoning (E963, E970-E979)	8	11.68	.68
Alcoholism (E980-E985)	0	2.82	--
All other causes (Residual)	45	44.71	1.01

Expected numbers for cancer deaths adjusted for Hampden County, Mass. rates
 Significant at the 5% level

Table II

Observed and Expected Deaths by Age at Death

Cause of Death	Age at Death: 20-49			50-69			70+		
	Observed	Expected†	P.M.R.	Observed	Expected	P.M.R.	Observed	Expected	P.
Malignant neoplasms	17	15.48	1.10	69	70.09	.98	32	31.18	1
Buccal cavity and pharynx	0	0.58	--	2	2.96	.68	1	0.89	1
Digestive organs and peritoneum	10	3.97	2.52	25	23.40	1.07	11	11.83	
Biliary passages and liver	1	0.13	7.69	2	0.95	2.11	0	0.43	
Pancreas	3	0.76	3.95*	3	4.25	.71	0	1.87	
All other digestive organs	6	3.07	1.95	20	18.36	1.09	11	9.64	1
Respiratory system	3	4.16	.72	20	22.50	.89	1	6.68	
Genital organs	1	0.48	2.08	6	3.60	1.67	7	4.71	1
Prostate	0	0.08	--	5	3.46	1.45	7	4.74	1
All other genital organs	1	0.26	3.84	1	0.14	7.14	0	0.04	
Urinary organs	0	0.60	--	3	3.95	.76	4	2.13	1
Other and unspecified sites	2	2.59	.77	7	6.89	1.02	6	2.40	2
Leukemia and aleukemia	0	0.86	--	2	2.09	.96	0	1.14	
Lymphomas	1	1.64	.61	4	3.80	1.05	2	1.27	1

†Expected numbers for cancer deaths adjusted for Hampden County, Mass. rates

*Significant at the 5% level

Table III

Observed and Expected Deaths by Year of Death

Year of Death:	1950-1959			1960-1969			1970-1976		
Cause of Death	Observed	Expected†	P.M.R.	Observed	Expected	P.M.R.	Observed	Expected	P.M.
Malignant neoplasms	32	26.77	1.20	46	48.55	.95	40	41.43	.9
Buccal cavity and pharynx	0	1.13	--	1	1.89	.53	2	1.41	1.4
Digestive organs and peritoneum	12	10.64	1.13	17	16.19	1.05	17	12.37	1.4
Biliary passages and liver	0	0.42	--	1	0.81	1.23	2	0.28	7.0
Pancreas	1	1.52	.66	3	2.91	1.03	2	2.46	.8
All other digestive organs	11	8.82	1.25	13	12.52	1.04	13	9.73	1.3
Respiratory system	8	5.94	1.35	9	14.10	.64	7	13.30	.5
Genital organs	4	2.13	1.88	6	3.41	1.76	4	3.24	1.3
Prostate	4	1.94	2.06	4	3.18	1.26	4	3.15	1.3
All other genital organs	0	0.15	--	2	0.19	10.53	0	0.11	--
Urinary organs	2	1.62	1.23	4	2.76	1.45	1	2.31	.4
Other and unspecified sites	3	2.68	1.12	6	5.03	1.19	6	4.18	1.4
Leukemia and aleukemia	0	1.04	--	1	1.73	.58	1	1.33	.9
Lymphomas	3	1.50	2.00	2	2.78	.72	2	2.42	.8

†Expected numbers for cancer deaths adjusted for Hampden County, Mass. rates

*Significant at the 5% level

Table IV

Observed and Expected Deaths by Number of Years since Started Working

Number of Years since Started Working:	< 20 years			20-30 years			> 30 years		
Cause of Death	Observed	Expected†	P.M.R.	Observed	Expected	P.M.R.	Observed	Expected	P.M.
Malignant neoplasms	34	34.47	.99	41	40.20	1.02	43	42.05	1.
Buccal cavity and pharynx	0	1.38	--	2	1.59	1.26	1	1.14	.
Digestive organs and peritoneum	10	11.29	.89	16	13.09	1.22	20	14.80	1.
Biliary passages and liver	0	0.44	--	1	0.50	2.00	2	0.57	3.
Pancreas	1	1.93	.52	2	2.39	.84	3	2.53	1.
All other digestive organs	9	8.96	1.00	13	10.28	1.26	15	11.84	1.
Respiratory system	8	9.57	.84	9	12.33	.73	7	11.42	.
Genital organs	4	1.82	2.20	5	2.57	1.95	5	4.38	1.
Prostate	2	1.36	1.47	5	2.46	2.03	5	4.36	1.
All other genital organs	2	0.27	7.41*	0	0.11	--	0	0.06	-
Urinary organs	2	1.81	1.10	1	2.25	.44	4	2.62	1.
Other and unspecified sites	5	4.13	1.21	5	4.13	1.21	5	3.62	1.
Leukemia and aleukemia	1	1.41	.71	1	1.31	.76	0	1.38	-
Lymphomas	4	2.40	1.67	2	2.29	.87	1	2.04	0.

†Expected numbers for cancer deaths adjusted for Hampden County, Mass. rates

*Significant at the 5% level

Table V

Observed and Expected Deaths by Place of Birth

Cause of Death	U.S. Born			Foreign Born		
	Observed	Expected†	P.M.R.	Observed	Expected	P.M.R.
Malignant neoplasms	80	82.13	.97	38	34.63	1.10
Buccal cavity and pharynx	2	3.22	.62	1	1.23	.81
Digestive organs and peritoneum	29	26.24	1.11	17	12.96	1.31
Biliary passages and liver	2	0.97	2.06	1	0.52	1.92
Pancreas	4	4.33	.92	2	2.05	.98
All other digestive organs	23	20.63	1.11	14	10.47	1.34
Respiratory system	18	24.84	.72	6	8.51	.71
Genital organs	10	5.06	1.98*	4	3.71	1.08
Prostate	9	4.59	1.96*	3	3.67	.82
All other genital organs	1	0.37	2.70	1	0.09	11.11
Urinary organs	4	4.46	.90	3	2.22	1.35
Other and unspecified sites	10	8.87	1.13	5	2.99	1.67
Leukemia and aleukemia	2	2.90	.69	0	1.20	--
Lymphomas	5	5.09	.98	2	1.61	1.24

† Expected numbers for cancer deaths adjusted for Hampden County, Mass. rates

* Significant at the 5% level

Appendix A

Ratios of Hampden County to U.S. Cancer Mortality Rates, White Males, 1950-1969

Cause of Death	Hampden County Rate*	U.S. Rate	Adjustment Factor
Malignant neoplasms	192.5	174.04	1.11
Buccal cavity and pharynx	≈ 7.0	≈ 5.36	≈ 1.31
Digestive organs and peritoneum	≈ 71.3	≈ 58.30	≈ 1.22
Biliary passages and liver	5.5	5.16	1.07
Pancreas	11.0	9.63	1.14
All other digestive organs	≈ 54.8	≈ 43.51	≈ 1.26
Respiratory system	42.2	40.95	1.03
Genital organs	≈ 20.0	≈ 18.67	≈ 1.07
Prostate	19.4	17.84	1.09
All other genital organs	≈ 0.6	≈ 0.83	≈ 0.72
Uterinary organs	11.9	10.64	1.12
Other and unspecified sites	≈ 10.0	≈ 10.73	≈ 0.93
Leukemia and aleukemia	8.5	8.81	0.96
Lymphomas	9.8	8.94	1.10

*Rate per 100,000 population

APPENDIX B

WORK EXPERIENCE BY DEPARTMENT OF PROSTATE CANCER DEATHS

DEPARTMENT

Sheet Resinox Saflex Vuepak Lustrex PVC Yard Shipping Law Maintenance Storeroom Guards

U. S. Born

Case 1						X					X
Case 2	X				X						
Case 3	X				X						
Case 4		X									
Case 5			X	X		X					
Case 6	X				X						
Case 7			X						X		X
Case 8	X		X								
Case 9								X			

Foreign Born

Case 1	X										
Case 2						X		X			
Case 3	X										

Legend: Sheet - Cellulose nitrate, cellulose acetate.
 Resinox - Phenol - formaldehyde resins.
 Lustrex - Polystyrene.
 Saflex - Polyvinyl butyral.
 Vuepak - Cellulose acetate.
 PVC - Polyvinyl chloride.

X = Most Representative Department
 X = Ever Worked Department