

VII. Summary

This report has presented the long-term cause-specific mortality patterns for employees and ex-employees of a large chemical producing plant owned and operated by the Monsanto Company. A cohort was developed from company records consisting of 2490 male wage-earners who were employed a minimum of one year between January 1, 1949 to December 31, 1966. The cohort was verified to be complete via a method which is independent of company-held records. Vital status of the cohort was determined as of December 31, 1976 for all but 7 persons (99.7% follow-up). A total of 603 study members were found to have died. Death certificates were located for 591 or 98.0 percent. The observed mortality among chemical-production workers was compared to the mortality experience of white males in the general populations of the United States, Massachusetts, and the county from which the work force was largely drawn (Hampden County). Findings of most interest are:

- (1) The overall mortality of chemical production workers, as reflected by a Standardized Mortality Ratio of 95.8 (U.S. control), was favorable, as would be expected in an employed population. Slightly lower SMR's for all causes of death were observed based on the state and county controls.
- (2) For most malignant neoplasms studied, the U.S. based SMR's were larger than those derived from the Massachusetts and Hampden County mortality experiences. However, SMR's for malignant neoplasms based on the two regional control populations were, generally, very similar.

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- (3) Mortality from all malignant neoplasms resulted in an SMR of 98.5 (county control). Positive gradients in SMR's were observed relative to calendar time, age, and the interval from onset of employment, suggesting the influence of occupational factors on the overall cancer mortality experience.
- (4) Based on Hampden County comparisons, elevated SMR's were observed for the overall category of digestive system cancer (SMR=101.8) and the individual sites of stomach (SMR=130.3), rectum (SMR=136.1) and biliary passages and liver (SMR=150.4). SMR's for esophageal cancer (136.5) and pancreatic cancer (116.3) were elevated only following 20 years from onset of employment. None of the digestive cancer excesses were statistically significant, however, the rectal, liver, and pancreatic cancers showed evidence of a relationship with both the duration and the lapsed period from onset of employment. The possible relationship between occupational factors and digestive system cancer mortality was confounded by other factors, such as birth place, which appeared to partly account for some of the excesses observed.
- (5) A statistically significant ($P<.05$) excess in deaths from genito-urinary tract cancers was observed based on the U.S., state, and local comparison populations. (SMR's = 169.4, 162.2, and 153.6, respectively). Elevated SMR's were also observed for all individual sites, although, none were statistically significant. The genito-urinary cancer excesses did not appear to be related to calendar time, duration of employment, or to the interval from

onset of employment, although a suspicious clustering of deaths was observed among those study members who worked a total of 10-20 years and who died within 20-30 years from the onset of employment. It is possible that occupational factors could have accounted, at least in part, for the observed excesses in genito-urinary tract cancers.

- (6) The only elevated SMR for cancers of the lymphatic and haematopoietic tissues was observed for the residual category "All Other Lymphopoietic Tissue" (4 deaths, county SMR=159.9). Although the small numbers involved prohibited detailed analysis, the presence of three multiple myeloma deaths within this category may be important and should be examined with respect to work histories in future studies.
- (7) Based on U.S. comparisons, deficits in deaths were observed for "All Heart Diseases" (SMR=98.2), rheumatic heart disease (SMR=44.1), and hypertensive heart disease (SMR=90.7). An elevated SMR of 108.8 was found for coronary heart disease. Comparisons with the state and county heart disease mortality experience during 1960-1976 generally produced lower SMR's.
- (8) Based on comparisons with U.S. white males, mortality from influenza and pneumonia was greater than expected (SMR=130.2) and was found to increase with calendar time, age, and the lapsed period from onset of employment. Comparisons with the state and county controls eliminated or reduced the excess; however, the gradient with time from initial employment was maintained. It is unclear whether occupational or nonoccupational factors are

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related to these mortality patterns.

- (9) Statistically significant deficits in deaths were observed for the categories "All External Causes of Death", "All Accidents", and "Motor Vehicle Accidents" (U.S. control). Mortality was greater than expected for motor vehicle accidents, suicides, and homicides when comparisons were based on the state and county control populations.

The results of this study underscore the importance and necessity of additional studies designed to further evaluate the mortality patterns of the Indian Orchard plant workers in relation to work history and occupational exposures.

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V. Summary and Conclusions

This report has presented the results of a matched case-control study of digestive and genito-urinary system cancers which were previously reported to have occurred in excess among employees and ex-employees of a large chemical producing plant owned and operated by the Monsanto Company. Based on an earlier historical-prospective study of these workers, 26 cases of genito-urinary system cancer and 42 cases of digestive system cancer were identified between January 1, 1950 and December 31, 1976. The primary objective of the present case-control study was to determine if any association could be demonstrated between the digestive and genito-urinary cancers and certain chemical agents and/or conditions which were specific to the work environment of the Springfield plant.

A matched design was used with two series of controls selected for each case (on a 1:4 case:control ratio). Series I controls were matched on race and age, whereas, Series II controls were matched on race, age, hiredate, and place of birth (digestive system cancer only). The problem of defining worker exposure in this study was handled by classifying over 130 department codes into 21 homogeneous Occupational Exposure Categories (OEC's). Matched odds ratios were computed by exposure period within each of the 21 OEC's for the two overall cancer categories and for the specific sites of esophagus, stomach, large intestine, rectum, liver, pancreas, prostate, kidney, and bladder.

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The findings of most interest are:

- 1) A comparison of the cases with the Series I controls did not support the hypothesis that the digestive or the genito-urinary system cancer experience at the Springfield plant is related to a general workplace exposure.
- 2) Since Series I controls are matched on date of birth and there was little difference between cases and controls in the average calendar year of hire, it was also assumed that age at hire was not a risk factor for any of the cancer sites examined.
- 3) Using Series I controls, a statistically significant ($P < .05$) odds ratio of 8.90 based on four exposed cases was observed for rectal cancer among workers employed for periods greater than five years in OEC VIII (cellulose nitrate production). No reliable interpretation could be made of this finding due to the small numbers involved, the lack of historical exposure information, and the absence of recent literature demonstrating an association between rectal cancer and any of the chemicals known to have been used or produced in OEC VIII.
- 4) Using Series I controls, a nearly statistically significant ($P = 0.06$) elevated odds ratio of 11.33 based on three exposed cases was observed for prostatic cancer among workers employed more than five years and among workers employed more than 10 years in OEC II (polystyrene processing). An examination of work histories revealed that all of the cases may have been exposed to cadmium-based compounds which were used as coloring agents in OEC II. This finding at Springfield could possibly be consistent with recent studies of rubber workers which have reported excesses in prostatic cancer among employees in the compounding and mixing areas where cadmium-based compounds were also used as coloring agents and rubber accelerators. The practical significance of this finding was greatly weakened, however, when consideration was given to both the very sporadic and limited usage of cadmium in OEC II and the lack of any observed prostatic cancer excess in an independent work area of the plant (OEC IV) which was associated with similar cadmium exposures.
- 5) The previously reported excesses among Springfield plant workers for digestive and genito-urinary cancers other than rectal and prostatic did not appear to be related to employment in any of the 21 OEC's examined in this report.

The methodological problems related to multiple comparisons, small numbers of deaths, uncertainty of exposures, and inconsistencies of results, did not permit definite conclusions to be drawn from this study. However, despite these limitations, the statistically significant rectal cancer excess and the nearly statistically significant prostatic cancer excess noted in specific OEC's of the Springfield plant may be important and as such warrant continued surveillance and further study. A recommendation was made to extend the follow-up period of the original cohort study so that additional rectal and prostatic cancers may be identified and augmented to the present case-control study. Such continued surveillance would enable the trend in the observed risks to be examined and would permit a more definitive assessment to be made concerning the causal nature of these suspected associations.