COLON AND STOMACH CANCER MORTALITY AMONG AUTOMOTIVE WOOD MODEL MAKERS

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Introduction

Since 1979, epidemiologic studies on cancer risks among pattern and model makers have focused on colon cancer. Three studies, commissioned by a major automobile manufacturer on overlapping groups of its own model makers, have all indicated excess risks for cancer of the colon and other sites among automotive wood and other pattern and model makers.[1-3] In 1979, the U.S. National Institute for Occupational Safety and Health (NIOSH) was asked by the United Auto Workers and by the General Motors Corporation to investigate indications of excess colon cancer and other cancers among automotive wood workers. In 1980, NIOSH researchers published a proportionate mortality ratio study on members of the Pattern Makers' League of North America in which excess colon cancer mortality was confirmed for wood pattern makers.[4] In 1985, NIOSH researchers published a detailed industrial hygiene investigation of exposures in automotive wood working shops. This survey did not identify known agents or exposure levels which would explain the apparent excess risk for colon or other cancers.[5-6] We now report the findings of a retrospective cohort mortality study of automotive wood model makers and the findings of case-control studies for colon and stomach cancer mortality within the cohort.

Methods

Cohort: **1. Selection.** The cohort included all automotive wood model makers who had worked for at least 1 month at one plant of each of the three major U.S. automobile companies in metropolitan Detroit, Michigan, at any time between 1940 and 1980.

2. Exposure. We used total duration of employment at the three study plants as a proxy measure for exposure. **3. Follow-up.** Vital status was followed through December 31, 1984, using the records of the Social Security Administration and the National Death Index. Death certificates were coded by a nosologist according to the appropriate revision of the International Classification of Diseases (ICD). **4. Analysis.** The cohort was analyzed using a modified life table system.[7] Person-years at risk of dying were accumulated from the date 1 month after the start of wood model making at a study plant until either death or the end of the study. Expected deaths were calculated by multiplying person-years by the U.S. mortality rates for white males.

Case-Control: **1. Case definition.** We defined cases as cohort members who died from colon (ICD 9th Revision, 153) or stomach cancer (ICD 9th Revision, 151) according to the underlying cause of death stated on their death certificates. **2. Control Selection.** We selected 15 controls per case matched on year of birth. Controls were selected at random from the pool of potential controls consisting of all members of the cohort who survived to the age at which the case died.[8] **3. Exposure.** We used both duration of employment in wood model making and cumulative weighted exposure to wood dust as exposure variables. To calculate duration of employment, we coded work histories for all jobs at the study plants. This allowed us to remove time spent laid off, on leave, or working in jobs with exposures other than wood. To calculate the cumulative weighted exposure to wood dust, each job was given an exposure assignment--high, medium, and low wood dust; plastics; metals; and solvents. A total of 106 personal wood dust samples were used to calculate geometric means in mg/m^3 for our three wood dust categories. The geometric means were then multiplied by the duration worked in each job and summed for all jobs. **4. Prior Exposure.** We collected available information on employment prior to the three study plants. Each case or control was assigned a "yes," "no" or "missing" depending on whether he had exposure to wood working from prior employment. **5. Analysis.** We used conditional logistic regression models[9] to test six measures of plant exposure to wood model making: 1) duration employed, 2) duration employed lagged by 10 years, 3) duration employed after 1955, 4) cumulative weighted wood exposure, 5) cumulative exposure weighted wood

exposure lagged by 10 years, and 6) cumulative weighted wood exposure after 1955.

Results

1. Cohort: Cohort Status. Vital status follow-up for the cohort is indicated in Table 1. **2. Cohort Exposure.** The mean duration of employment was 15 years; other descriptive statistics for the cohort are also given in Table 1. **3. Cohort Mortality.** The SMR for all causes of death was 0.8 (95% C.I., 0.73-0.85), a statistically significant deficit. Diseases with significant deficits in mortality risk included: heart disease, cerebrovascular disease, respiratory disease and nonmalignant digestive disease. No cause of death was estimated to be statistically significantly elevated. Statistically nonsignificant excess mortality risks were estimated for cancers of the stomach, colon, and for other digestive cancers as well as for cancers of the kidney and brain and for unspecified neoplasms.
4. Colon and Stomach Cancer Mortality. The SMRs for colon and stomach cancer mortality compared to U.S. mortality rates are shown by decade in Table 2. Except for the period 1940-49, for which the colon cancer SMR was 5.0, the SMRs by decade were relatively unchanging in general agreement with U.S. colon cancer mortality rates from 1940 to 1984.[10] The SMRs for stomach cancer by decade increased over time when measured against the U.S. stomach cancer mortality rates which decreased steadily from 1940 to 1984.[10]

Case-control: 1. Case Definition. Twenty of the deaths due to colon cancer and 17 of the deaths due to stomach cancer observed in our cohort study were defined as cases in our case-control studies. **2. Control Selection.** A total of 543 controls were included in the study--293 in the colon cancer and 250 in the stomach cancer analyses. Table 3 gives statistics on some of the relevant variables for cases and controls. **3. Analysis** Table 4 gives the means for cases and controls for our six wood-exposure variables for both colon and stomach cancer. None of our six wood-exposure variables indicated a significant positive dose-response for either colon or stomach cancer mortality. All of the logistic regression coefficients for wood-exposure variables were negative. Table 4 also shows the odds ratios indicating the change in risk for 20 years of exposure calculated from these coefficients. The 12 odds ratios in Table 4 are for models which included only the single wood-exposure variable specified. We included the following variables in the logistic

regression models to test for confounding or interaction with the exposure variables: year first employed, years since first employment, prior employment in wood model making, exposure to metals, exposure to plastics, and plant. All these variables were dropped from the final models shown in Table 4 because we found no model in which the coefficients for the wood-exposure variables changed appreciably as a result of their inclusion.

Discussion

This is the first analysis of automotive wood model makers in which associations between specific exposures associated with wood model making and both colon and stomach cancer mortality have been tested. In performing these tests our analyses had the following strengths, we: (1) lagged our exposure variables by 10 years to account for latency, (2) tested exposures only after the introduction of impregnated wood products in 1955, (3) adjusted for prior exposure to wood model making and other occupational exposures, and (4) ascertained deaths over a period of 44 years, over four times longer than other studies.[1-4]

The elevated risk for colon cancer mortality in our cohort analysis (SMR=1.2, 95% C.I., 0.8-1.9, based on 21 observed deaths) was lower than observed in other mortality and incidence analyses of pattern and model makers.[1-4] Misclassification of colon and rectal cancer as the cause of death on death certificates has been noted.[11] Had we used a combined category for colon and rectal cancer, our SMR would have fallen to 1.0, 95% C.I. 0.6-1.5. The elevated risk for stomach cancer mortality in our cohort analysis (SMR=1.6, 95% C.I., 0.9-2.6, based on 17 observed deaths) was higher than observed in other mortality and incidence analyses of pattern and model makers.[1-4]

Epidemiologic results must be interpreted in terms of the endpoints chosen for analysis. Cancer incidence is more appropriate than mortality as a measure of risk (endpoint) for diseases such as colo-rectal cancer where there is relatively good survival. The U.S. 5-year survival rate for the period 1979-1984 was 53 percent.[10] This was less important for stomach cancer with a 5-year survival rate of 16 percent over the same period.[10] Two of the previous studies[1,2] used incidence rather than mortality as their endpoints.

Differences between our results and the results of other studies[1-4] may have been attributable to differences in length of follow-up, the fact that incidence rather than mortality was observed in some other studies and in the populations chosen for analysis. However, limitations and potential biasing factors in both our studies must also be considered.

A major limitation of our cohort analysis was the lack of information about work in wood model making before employment in the three study plants. This provided the main rationale for using our nested case-control studies, not our cohort study, to test the relationships between wood model making exposures and colon and stomach cancer mortality. The mean age first employed at a study plant for men in the cohort was 34 years (Table 1). A review of work records from the three study plants showed that a high percentage of these men had had previous experience in wood model making (Table 3). Therefore we reported only overall SMRs from our cohort analysis because we decided that SMRs by duration of employment and time since first employment, based only on employment at the study plants, were not meaningful for testing exposure-disease relationships.

We attempted to account for prior exposure in our case-control studies by collecting the available data on prior employment for cases and controls and including a variable for prior employment in our logistic regression models as a possible confounder. After controlling for prior employment in wood model making and for other possible confounding or interaction variables in our logistic regression models, we found no positive association between plant exposure to wood model making and risk of mortality for either colon or stomach cancer (Table 4).

In summary, in our cohort analysis we found elevated SMRs for colon and stomach cancer for automotive wood model makers compared to U.S. rates, although neither SMR was statistically significant. The SMR for stomach cancer approached statistical significance and, unlike the SMR for colon cancer, remained elevated even when compared to local mortality rates to control for ethnicity. In our nested case-control analyses, we found odds ratios for colon and stomach cancer mortality within this cohort which did not indicate an association with cumulative occupational exposure to

wood model making within our ability to measure it. Any future analyses of colon and stomach cancer should include: (1) more direct quantification of occupational exposures, (2) quantification of other risk factors, such as diet, ethnicity, and family history, and (3) specific pathology information on disease incidence.

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Table 1. Automotive wood model makers cohort 1940-1984

A. Vital status	Number	(%)
Alive	1,560	(68%)
Deceased	706	(31%)
Certificate Obtained	691	(98%)
Certificate Not Obtained	15	(02%)
Unknown	28	(01%)
Total	2,294	(100%)
Person-years	57,378	

B. Cohort characteristic	Mean
Year of birth	1919
Year first employed	1953
Age first employed	34 years
Duration employed	15 years
Age at end of study	60 years
Time since first employment	26 years

Table 2. Colon and stomach cancer SMRs for white male model makers by decade: U.S. rates comparison

Site	Decade 1940-49	1950-59	1960-69	1970-79	1980-84	Total
Colon						
SMR	5.0	0.9	1.0	1.0	1.3	1.2
95%CI	1.4-12.8	0.1-3.3	0.3-2.6	0.4-2.1	0.4-3.1	0.8-1.9
obs/exp	4/0.8	2/2.2	4/4.0	6/6.2	5/3.8	21/17.0
U.S. rate per 100,000 males[10]	27	25	25	25	24	25[a]
Stomach						
SMR	0.8	0.4	1.8	2.1	3.1	1.6
95%CI	0.02-4.2	0.01-2.3	0.6-4.2	0.8-4.7	0.8-7.9	0.9-2.6
obs/exp	1/1.3	1/2.3	5/2.8	6/2.8	4/1.3	17/10.5
U.S. rate per 100,000 males[10]	29	20	17	10	7	10[a]

[a] 1982-1983 mortality rate per 100,000 males

Table 3. Case-control data: colon and stomach cancer

	Year of death /plant	Age at death	Years since employed	Year first employed	Prior wood employment	Plant metal employment	Plant plastic employment
			Colon Cancer				
Case means N=20	1969	66	25	1944	60% yes	10% yes	10% yes
Control means N=293	---	--	24	1945	48% yes	7% yes	4% yes
			Stomach Cancer				
Case Means N=17	1970	66	22	1948	59% yes	0% yes	6% yes
Control Means N=250	---	--	22	1947	55% yes	10% yes	6% yes

Table 4. Case-control analysis: wood exposure means and odds ratios

Wood Exposure Variable	[—Colon Cancer—] Case Means[a]	Control Means[a]	Odds Ratio[b]	[—Stomach Cancer—] Case Means[a]	Control Means[a]	Odds Ratio[b]
Weighted wood exposure (mg/m^3-years)						
Cumulative exposure	4.2	6.8	0.2 0.02-1.6	5.5	6.2	0.7 0.2-3.4
Cumulative exposure lagged by 10 years	2.9	4.8	0.2 0.01-2.2	4.3	4.4	0.9 0.2-5.0
Cumulative exposure after 1955	1.7	3.2	0.1 0.002-3.1	2.9	3.5	0.6 0.1-6.2
Duration employed in wood (years)						
Cumulative duration	10.8	15.2	0.4 0.1-1.0	12.0	13.8	0.6 0.2-2.0
Cumulative duration lagged by 10 years	7.9	11.3	0.3 0.1-1.1	8.2	10.2	0.5 0.1-2.0
Cumulative duration after 1955	3.6	5.9	0.2 0.03-1.2	5.3	6.2	0.5 0.1-3.6

a. Unmatched
b. Odds ratios and 95% confidence intervals for 20 versus 0 years exposure.

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