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A Follow-Up Study Of Mortality And A Nested Case-Control Study Of Stomach Cancer Among Foundry And Automobile Engine Manufacturing Plant Workers.

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A FOLLOW-UP STUDY OF MORTALITY AND A NESTED CASE-CONTROL STUDY OF STOMACH CANCER AMONG FOUNDRY AND AUTOMOBILE ENGINE MANUFACTURING PLANT WORKERS

by

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A DISSERTATION

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ABSTRACT OF DISSERTATION
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Title A Follow-up Study of Mortality and a Nested Case-Control Study of Stomach Cancer Among Foundry and Automobile Engine Manufacturing Plant Workers.

A retrospective follow-up study (RFS) of the mortality experience of 21,013 workers employed at a foundry and two engine manufacturing plants was conducted to determine if these workers had any unusual death rates for all causes and for specific causes. A total of 2,235 deaths occurred during the follow-up period of 1970 to 1987. Mortality from all causes was lower than expected. Male subjects experienced a 6-13% excess of lung cancer deaths, depending on the choice of the comparison group. The excess was statistically significant for men with 20+ years of employment and displayed a positive trend with increasing duration of employment. However, this was not statistically significant after adjusting for years since hire (p=0.09). White men experienced a statistically significant excess of deaths from stomach cancer when compared with the US white men. Black men had increased mortality from pancreatic cancer, especially among engine plant workers, and an excess of prostate cancer, concentrated among foundry workers.

A nested case-control study of stomach cancer which included the 30 cases of stomach cancer occurring among subjects in the RFS and 116 controls selected from this cohort was conducted to determine if stomach cancer was related to various occupational and lifestyle factors. Stomach cancer was associated with employment in the engine plants but not in the foundry. For one of the engine plants, there was evidence of dose-response between years worked and stomach cancer risk (p=0.04). In this plant there was an elevated relative rate (RR) for machining, packaging, assembly, and administration departments, but only the association pertaining to the machining departments was statistically significant. The RR for machining of cast iron products was elevated (RR=2.6; 95% CI=1.5-5.9). Analysis by job titles found elevated RRs for grinders (RR=1.5) and for maintenance workers (RR=2.2). Study findings were equivocal with respect to potential cutting fluid exposure. However, accurate assessment of cutting fluid exposure was compromised by lack of complete industrial hygiene data at this complex. Foreign birthplace of the subject or either parent was positively associated with stomach cancer mortality.

Abstract Approved by: Committee Chairman ______

Program Director ______

Date ______ Dean of Graduate School Terry L Hickey

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LIST OF ABBREVIATIONS

BP:	Brook Park
PAH'S:	Polycyclic aromatic hydrocarbons
PMR:	Proportional mortality ratio
SMR:	Standardized mortality rate ratio
RFS:	Retrospective follow-up study
WHF:	Work history file
MR:	Mortality Registry
SSN:	Social security number
SSA:	Social security administration
PBI:	Pension benefit information
NDI:	National death index
DMV:	Department of motor vehicle
PY:	Person years
OHMI:	State death tapes for Ohio and Michigan
SAS:	Statistical Analysis System
RR:	Relative rates
GLIM:	Generalized Linear Integrated Model
ICD:	International classification of disease
OCMAP:	Occupational cohort mortality analysis program
IH:	Industrial hygiene
EOR:	Exposure odds ratio
MLE:	Maximum likelihood estimate

LIST OF ABBREVIATIONS (Continued)

CC:	Cuyahoga County
US:	United States
MPDS:	Mortality and population data system
CI:	Confidence interval

PART I RETROSPECTIVE FOLLOW-UP STUDY

Background

A recent unpublished proportional mortality ratio (PMR) study of workers at a foundry and engine manufacturing complex reported a proportional excess of cancer deaths among white (PMR=115) and black (PMR=175) men. The excess was due primarily to an elevated PMR for lung cancer among both white and black men (PMR=183; 95% confidence interval (CI)=138-228) and to an elevated PMR for stomach cancer among white men (PMR=192; 82-529). A proportional excess of deaths from arteriosclerotic heart disease among white (PMR=132; 111-152) and black men (PMR=146; 101-191) also was reported.

The complex is located in Cuyahoga County (CC), Ohio, and includes a foundry and two automobile engine manufacturing plants. The foundry opened in 1952 while engine plant 1 and engine plant 2 opened in 1951 and 1954, respectively.

The purpose of the present study is to investigate further the possible work-related disease excesses at these plants suggested by the PMR study described above. Because of the inherent limitations of PMR studies (1), a retrospective follow-up study (RFS) was undertaken to evaluate further the overall and disease specific mortality experience of these workers. A major limitation of this RFS is that work histories of cohort members were readily available only since 1973. Because of this limitation and because there was specific concern pertaining to the occurrence of lung and stomach cancer at these plants, in-depth case-control studies of these two diseases were undertaken, so that the entire work history of subjects could be examined. The RFS and the stomach cancer case-control study are described, respectively, in Part I and Part II of this report.

Methods

The investigation is a retrospective follow-up study (RFS). The cohort includes all hourly workers who were active at any time between January 1, 1973, and December 31, 1986, and former hourly employees who retired before 1973 and who were alive as of January 1, 1970. The observation period of the study is January 1, 1970, through December 31, 1987.

Cohort members were identified using records in a computerized work history file (WHF). This file includes a complete work history of all United States (US) employees of the company who were hired in 1973 or later and a partial work history, available only since 1973, of employees who were hired before 1973 and who were still active in 1973. Employees who retired before 1973 and who were alive as of January 1, 1970, are included in the WHF, but information pertaining to their work history is not available. Workers who terminated employment before 1973 are not included in the WHF. The WHF contains information on date of birth, gender, race, social security number (SSN), hire date, last active date, current employment status (active, terminated, or retired), payroll classification (hourly or salaried) and changes in employment status since 1973. There is also information on each job held since 1973, including the start date of the job, the location, the job title code and the department.

Vital status as of January 1, 1988, was determined either from the WHF, the company Mortality Registry (MR), state death tapes for Ohio and Michigan (OHMI), Pension and Benefit Information (PBI), Westat, the National Death Index (NDI), or the Ohio Department of Motor Vehicles (DMV) (figure 1). PBI and Westat are private companies that use Social Security Administration (SSA) death tapes to identify decedents. They do not, however, have data that will verify that an individual is still living. The death certificates of decedents were obtained from the appropriate state office of vital records and were reviewed by trained nosologists who coded the underlying cause of death according to the Ninth Revision of the International Classification of Diseases (ICD-9).

The overall and the cause-specific mortality rates of the cohort and of various subcohorts specified on the basis of race, gender, duration of employment, period of hire, plant and departments within the plants were compared with the corresponding mortality rates of the general United States population or of the population of CC. For these comparisons, the SMR served as the measure of association. The SMR was computed as the ratio of the observed number of cause-specific deaths among cohort members (or subgroups) to the expected number, multiplied by 100. The expected numbers were computed by first accumulating the person-years (PY) of observation of each cohort member, by allocating the accumulated PY to race (white or black) and gender-specific five-year age and calendar time categories and by multiplying the PY by the corresponding US or CC mortality rates. The resulting quantities were summed over the stratifying factors to obtain expected numbers. Software developed by Monson (2) and by Marsh (3) were used to accomplish this task. The CC rates were obtained from the Mortality and Population Data System (MPDS) maintained by the University of Pittsburgh (4). We estimated CI for the SMRs under the assumption that the observed number of deaths follows a Poisson distribution. The program developed by Rothman and Boice was used to obtain P-values and CI for SMRs (5).

For most analyses, it was assumed that subjects with unknown vital status were alive as of December 31, 1987. The assumption would over estimate the PY and expected numbers of events and, hence, underestimate SMRs. We evaluated the magnitude of this potential bias by censoring all cohort members who were terminated without vested benefits as of their termination date. This analysis yielded results that were similar to results obtained when subjects with unknown vital status were presumed living until the end of the study (Appendix A). Therefore, all results presented in the main body of this report are based on the uncensored procedure.

Relative mortality rates (RR) were used to compare the mortality experience of subgroups of workers employed in a specific department to those not so exposed. Maximum likelihood estimates of the RRs for ever versus never employed since 1973 in a particular department were obtained through the use of Poisson regression using the GLIM program after adjustment for age, race and calendar time (6,7). Dose-response was evaluated by considering length of employment in the department since 1973 as a surrogate for cumulative exposure. A statistical trend test for an evaluation of dose-response was performed by including in a Poisson regression model an ordinal variable denoting four categories (0, <5, 5-9, 10+) of years of employment, as well as age, race and calendar time.

The departments evaluated in the foundry include the molding, core room, melting, finishing/cleaning, the pattern shop, maintenance, material handling and administration. The departments evaluated in the engine plants include machining, assembly, maintenance, packaging and administration. The machining departments in the engine plant were further classified by the type of cutting fluids used in various operations since 1973. The three categories of cutting fluids evaluated were soluble oils, insoluble oils and synthetic fluids. The information on the type of cutting fluids was obtained from plant material fact sheets and material specification sheets. Departments within the machining section that performed dry (no cutting fluids) operations were also evaluated.

Finally, a number of specific job categories determined from job title codes in the WHF were evaluated. These included metal workers, tool makers, welders, material handlers, millwrights, pipe fitters, plumbers, grinders, mold and core room workers, and maintenance workers. These job categories were evaluated because they are more likely to entail exposure to potential carcinogens.

Results

The study cohort consisted of 18,770 men and 2,243 women (table 1). About 31% of cohort members were still employed as of the end of the follow-up period, 20% had retired, about 3% had died while actively employed, and 46% had terminated employment before becoming eligible for retirement benefits. A total of 2,235 (11%) cohort members died during the follow-up period, whereas 16,134 (77%) were known to be living as of December 31, 1987. The vital status of 2,644 (13%) cohort members was unknown as of the end of the follow-up period.

About 49% of male cohort members were hired before 1970, whereas almost all women were hired in 1970 or later (table 2). Approximately 80% of the cohort was followed for 10 years or more. The average duration of employment is 15 years for men and 10 years for women. Based on work history data starting in 1973, 5,833 (28%) subjects were employed only in the foundry, 7,324 (35%) were employed only in the engine plants, and 7,007 (33%) were employed in both.

Mortality Patterns of Women

The all cause SMRs is below 100 for both white (SMR=91) and black (SMR=46) women (table 3). Several cause-specific SMRs are elevated and several are below 100. However, this study has very little statistical power to detect an excess or deficit of cause-specific mortality among women because the total numbers of deaths (N=33) is so small. For this reason, subsequent analysis and discussions are restricted to men.

Mortality Patterns of Men

Deaths from all causes and from all cancer are less than expected for both white and black men (table 4). White men experienced significantly elevated mortality from stomach cancer (SMR=158; 101-234). The stomach cancer SMR for black men, based on 4 and 5.5 expected deaths, is slightly below 100. For lung cancer, there is an 11% excess (SMR=111; 95-128) among white men and a 21% excess (SMR=121; 89-161) among black men. The overall lung cancer SMR for white and black men combined is 113 (99-129), based on 224 observed and 198 expected deaths. Both white and black men have excess prostate cancer mortality (SMRs=112 and 175 respectively; overall SMR=126; 93-167). There is a non-statistically significant elevated SMR for kidney cancer among white men, but not among black men. The overall kidney cancer SMR is 118 (66-195). There is an excess of lymphosarcoma and of reticulosarcoma among white men (SMR=152; 69-288); no such deaths are observed among black men, whereas 0.8 were expected. There is an excess of Hodgkin's disease mortality both among Whites and Blacks (overall SMR=189; 76-389). Black men experienced a non-statistically significant excess of leukemia deaths (obs=5; SMR=173).

The SMR for all circulatory diseases is 95 (88-101) for white men and 72 (61-80) for black men. The arterio-sclerotic heart disease SMR is 92 (84-100) for white and 78 (62-97) for black subjects. Mortality from suicide is slightly increased for both white (SMR=114; 87-148) and black (SMR=118; 56-217) men. There is a significant deficit of deaths from respiratory diseases among both white and black men (overall SMR=71; 58-86). There are no unusual mortality patterns for other causes of death among either racial group.

<u>Stomach Cancer Mortality</u>

Stomach cancer SMRs for white men computed using US mortality rates for comparison are considerably higher than the SMRs computed using CC rates (table 5). There is no excess of stomach cancer mortality among black men, irrespective of the comparison group. Among white men, the excess is found among men who were first employed before 1955, (CC SMR=144; 85-228), who had 20 or more years since first hire (CC SMR=129; 80-197) and who worked for 20 or more years (CC SMR=156; 89-253). The data also display a dose-response relationship with respect to duration of employment. An internal comparison of the stomach cancer SMRs according to duration of employment yields a statistically significant positive trend (P=0.03). However, adjustment of this trend test for years since hire, yields a p-value of 0.09.

Lung Cancer Mortality

For white men, lung cancer SMRs computed using US mortality rates for comparison are similar to the SMRs computed using CC rates (table 6). There is an excess of lung cancer deaths among white men hired before 1955 (overall US SMR=116; 100-133), whereas among men hired in 1955 or later, the lung cancer US SMR is 104 (81-132). An analysis of lung cancer mortality in relation to years since first hire indicates a slight increase in lung cancer mortality rates among subjects with 20+ years since hire relative to men in the general US population (SMR= 119; 101-140). Among white men, excess lung cancer mortality is confined to workers with 20 or more years of employment (SMR=127; 105-153).

For black men the CC rate-based SMR is 15-22% lower than the US rate-based SMR. Excess lung cancer mortality is limited to workers with 15 or more years of employment (US SMR=136; 99-182). A trend test for increasing lung cancer mortality with increasing duration of employment for white and black men combined, yields a P-value of 0.008 without adjustment for year since hire and 0.16 with adjustment for years since hire.

Plant-Specific Mortality Patterns

The distribution of selected causes of death and the corresponding SMRs for men who had worked since 1973 only in the foundry, only in the engine plants or in both the foundry and engine plants is displayed in table 7. The lung cancer SMR for workers in the foundry (SMR=121; 94-152) is similar to the SMR for engine plant workers (SMR=123; 101-149). The CC-based lung cancer SMR is 113 (88-142) for foundry and 118 (96-143) for engine plant workers. The overall excess of stomach cancer is largely restricted to white men who worked in the engine plants (SMR=254; 142-420). The CC rate-based stomach cancer SMR for white men who worked in the engine plants is 188 (105-310). Further evaluation of stomach cancer among white men employed in the engine plants indicates that most of the excess occurs among subjects hired at the complex before 1960 and having 20 or more years of service and 20 or more years since first hire.

The 74% excess of prostate cancer observed in the overall cohort of black men is concentrated among those who worked only in the foundry (US SMR=234; 112-430) (CC SMR=208; 100-382). Nine of the 10 prostate cancer deaths among black foundry workers occurred among men hired before 1960 (CC SMR=202; 92-382). White foundry workers have a prostate cancer SMR of 93. Black men who worked only in the engine plants have a 2.5 to 3-fold increase in pancreatic cancer deaths (US SMR=303; 121-624) (CC SMR= 248; 100-511). White men have an SMR of 91 for this cancer. Other results of interest include non-statistically significant excesses of deaths from suicide (SMR=149; 98-219) among foundry workers and of deaths from motor vehicle accidents among black engine plant workers (SMR=179; 86-329). Both foundry (SMR=80; 54-114) and engine plant (SMR=54; 36-77) workers have deficits of deaths from nonmalignant respiratory diseases. These results are similar when CC rates are used for comparison.

Work Area-Specific Mortality Patterns

Tables 8 and 9 display RRs comparing the mortality experience of workers employed in specific foundry and engine plant work areas with the experience of workers not employed in these work areas. Employment in the foundry core room is associated with a slight excess of all cancer and of lung cancer mortality (table 8). These excesses are not statistically significant and do not display a dose-response relationship (data not shown). Material handling workers have a statistically significant increase in overall cancer mortality and in lung cancer mortality. The relationship between total cancer and between lung cancer mortality and material handling displays some evidence of dose-response (trend test P-value=0.03 and 0.007, respectively). There also is an excess of stomach cancer deaths in material handling, but this result is not statistically significant. Administrative workers have elevated all cancer and lung cancer RRs, but neither of these results approaches statistical significance.

For engine plants workers, there are small non-statistically significant excesses of lung and stomach cancer in the assembly and packaging work areas (table 9). An evaluation of duration of employment in assembly departments since 1973 indicates no consistent pattern for lung cancer but does display some evidence of dose-response for stomach cancer (P=0.06). No consistent pattern was observed for either cancer in the packaging departments.

<u>Other Analyses</u>

Analyses evaluating exposure to cutting fluids (soluble, insoluble or synthetic fluids) since 1973 did not display any unusual cancer mortality patterns. With the exception of material handlers (total cancer RR=1.4; 1.0-1.9) (lung cancer RR=1.16; 0.7-2.0) (stomach cancer RR=2 .5; 0.7-8.4), we did not observe any unusual or statistically significant mortality patterns associated with employment in any of the job categories examined.

Discussion

Several issues pertaining to validity have a bearing on the interpretation of this study. First, the proportion of subjects lost to follow-up is rather high (about 13%). If some of the subjects with unknown vital status in fact had died during the study period, SMRs in this study are underestimated. However, as already mentioned, SMRs computed under two censoring assumptions are similar. Because the "true" SMRs are probably somewhere between these two sets of SMRs, it is unlikely that any appreciable degree of bias was introduced by the assumption that the terminated with unverified vital status were alive on the study end date.

Work history information was available only since 1973, and subjects are, therefore, likely to be randomly misclassified with respect to plant, department and job. This problem has little or no effect on the evaluation and interpretation of the mortality experience of the overall cohort. However, it has serious implications with respect to the evaluation of specific departments and jobs, and the findings pertaining to these areas must be interpreted with caution, as discussed later.

A minor problem is the fact that 4.5% of decedents have an unknown cause of death. If one assumes that the cause of death among those with an unknown cause is distributed as is that for the decedents with a known cause, the all-cancer SMR is increased from 102 to 106, the lung-cancer SMR is increased from 113 to 118, and the stomach cancer SMR is increased from 135 to 141. As is seen, these changes are minimal.

There is an overall deficit of deaths among cohort members irrespective of the reference population, that is statistically significant for black men and women. Such deficits are not uncommon when the mortality experience of employed persons is compared to that of the general population and may be attributable to the combination of the selection of healthy individuals into the workforce and to the benefits derived from the physical fitness required for many jobs (8).

The all-cancer SMR for men is close to the null value when compared to the US population and is 8% lower than expected when compared to CC residents. Women appear to have appreciable deficit of cancer mortality, but the number of cancer deaths among women is too small to draw any meaningful conclusions.

The overall cohort of men experienced a small excess of lung cancer. The SMRs for this cancer increased with time since first hire and with length of employment. However, even among long-term employees and among subjects followed up for many years since first hire, the excess remained small, never exceeding 40%. Also, the excess could not be attributed clearly to any particular plant, work area or job. The only statistically significant result was for material handling in the foundry work area that is unlikely to entail exposure to hazardous chemicals. The work areas that entail relatively greater exposure to potential carcinogens (e.g., the core room, molding departments, finishing) were not associated with lung cancer in this study.

A possible explanation for the excess lung cancer deaths observed among material handlers is that these are high-seniority jobs and that most material handlers have spent a number of years in other departments, where they may have been exposed to lung carcinogens. It also must be borne in mind that work histories were available only since 1973 and that analysis by time since hire at the complex and by duration of employment indicated that any causal workplace exposure may have been sustained largely during the 1950s and 1960s, a time period for which we have no work history data. An evaluation of the complete work histories of a subset of subjects indicated that they moved quite frequently between departments and jobs, so that the information from 1973 onward would not necessarily reflect earlier work histories. The resulting misclassification of subjects by work area may have obscured any positive relation between lung cancer mortality and a specific work area or job.

Another factor which makes interpretation of the lung cancer results unclear is the absence of information on cigarette smoking. Cigarette smoking is the major cause of lung cancer (9), and differences between the smoking habits of cohort members and those of the general population comparison group could account for the small excess of lung cancer seen in this study. We used indirect procedures to evaluate this possibility (10). We determined whether the SMRs for other smoking-related causes of death were elevated, suggesting heavier cigarette smoking by cohort members. There were deficits of deaths due to emphysema (SMR=64; 36-106) and cancers of the larynx (SMR=62; 20-145) and esophagus (SMR=51; 23-97). The combined SMRs for emphysema and cancers of the larynx and esophagus among white men, black men and all men are 56 (35-86), 69 (30-137), and 59 (40-85), respectively. The observed number of all respiratory disease deaths also is significantly below its expected value (SMR=71; 58-86). This significant deficit of deaths due to other smoking-related diseases suggests that the excess lung cancer probably is not related to smoking and confers greater importance to the lung cancer excesses seen among cohort members.

The elevated mortality from lung cancer among this cohort of foundry workers is consistent with the findings of other studies. There is a substantial body of evidence supporting an association between foundry work and lung cancer mortality (11-24). A recent review of the pertinent literature indicates that lung cancer mortality was elevated by an average of 43% across 14 studies, and in no study was the number of lung cancer deaths less than that expected (20). This consistent reporting of excess lung cancer mortality is in agreement with the presence of respiratory tract carcinogens in the ambient air of foundries (19,25-27). However, the possibility that some of the excess is attributable to chance and to confounding by smoking and other unidentified factors cannot be ruled out.

The excess of stomach cancer deaths among white men at the complex compared to the US general population was reduced considerably when employees were compared with CC residents. This suggests that much of the apparent excess is due to confounding by non-occupational factors. Several such factors (e.g., diet, country of birth and socio-economic status) have been associated with an increased risk of stomach cancer (27-29). Also, previous studies have reported a large amount of geographical variation in stomach cancer rates (30-32). In the US, such variation has been attributed to the presence in some regions of relatively high proportions of foreign-born persons who migrated from countries with elevated stomach cancer incidence and mortality rates such as Japan, Iceland, Central and Eastern Europe and most of Latin America (31-34). A review of the death certificates of the 24 stomach cancer cases among white men revealed that 15 were born in the US. Three of the remaining 9 cases were born in Poland, 3 in Yugoslavia, and one each in Greece, Italy and the Ukraine.

Although the magnitude of the association found between stomach cancer mortality and engine plant employment decreased with the use of CC rates, the CC-based SMR remained statistically significant and displayed a dose-response relationship with duration of employment at the complex. In balance it is likely that some, but not all, of the observed excess of stomach cancer among white engine plant workers is accounted for by confounding by a correlate of geographic region.

The finding that the excess of stomach cancer was concentrated among engine plant workers in this study is consistent with the results of previous epidemiologic investigations (35-45) and with experimental data demonstrating the carcinogenic potential of certain cutting fluids which were present in some work areas at the complex (46,47). In a study of automobile engine plant workers, Vena and associates (36) reported significant proportional excess of gastrointestinal cancer (PMR=190) among workers with more than 20 years of employment. The excess was attributed to exposure to oil mist generated during grinding and spray lubricating. Decoufle reported a statistically significant two-fold excess of cancer of the stomach and large intestine among workers with at least 20 years of latency in machining jobs that entailed exposure to both insoluble and soluble oils (39). Dubrow and Wegman, in a study based on Massachusetts death certificate data, reported a positive association between machinist jobs and stomach cancer (35). Silverstein et al. reported a PMR of 339 for stomach cancer among white men with more than 10 years of exposure to metal working fluids in a bearing plant, and attributed this association to grinding operations using water-based cutting fluids (37). In a similar PMR study of bearing plant workers, Park and co-investigators reported a PMR of 200 and attributed the excess to precision grinding done predominantly with water-based cutting fluids (38). Jarvholm also reported an increased gastrointestinal cancer (SMR= 136; observed=9) among grinders with at least 5 years employment and at least 20 years of latency in operations that entailed exposure to cutting fluids (43). On the other hand, several epidemiologic studies have found no association between exposure to oil mists and stomach cancer (48-50).

In the present study, analysis by department in the engine plants did not indicate any association with the machining work area, where exposure to oil mist might be expected to have been relatively high. Furthermore, the evaluation of soluble, insoluble and synthetic cutting fluids as well as dry machining did not suggest an association with stomach cancer. Thus, the results of this study do not support the positive findings from the other studies described above. However, the limitations of our analyses of stomach cancer rates by department and by oil mist exposure are the same as for the analyses of lung cancer (limited work histories), and the problems are exacerbated by small numbers of stomach cancer deaths.

Mortality patterns seen for several specific types of cancer warrant further discussion. Both pancreatic and prostate cancer displayed statistically significant increases in certain race- and plant-specific subcohorts. Black engine plant workers had a statistically significant excess of pancreatic cancer, and black foundry workers had a statistically significant excess of prostate cancer. No department or job was found to be associated with excess deaths from either cancer. Furthermore, the elevated SMRs for these two cancers did not display any consistent pattern with respect to time since first hire or duration of employment at the complex. Because the observed excesses of deaths from pancreatic and prostate cancer were present for one racial group (black men) only and because of the lack of a consistent pattern with time since first hire and duration of employment, it is unlikely that these excesses are related to workplace exposures. However, previous studies among similar industrial workers have reported increased mortality from prostate cancer (20,36, 48,51) and from pancreatic cancer (20,36,37,52). Silverstein and co-workers reported excess pancreatic cancer deaths among ball bearing manufacturing plant workers and noted that pancreatic cancer deaths increased with increasing duration of employment in grinding and machining jobs (37). Also, Breslin found an excess of prostate cancer in his study of foundry workers (51) and Vena reported a slight excess of this cancer in his study of engine plant workers (36). Recently, Andjelkovich and co-workers reported a non-significant excess of deaths from pancreatic and prostate cancer in their study of foundry workers (20).

CONCLUSIONS

The results of this study are consistent with the small excess of lung cancer and with the association between engine manufacturing and stomach cancer reported in earlier investigations. We were unable, however, to identify any specific department, job, or process as the source of the excess deaths. Our failure to do so may reflect the limitations of the study design. Another explanation is that the overall excesses may be due, all or in part, to confounding by factors such as country of birth and smoking habits.

We are conducting two nested case-control studies, one of lung cancer and the other of stomach cancer, among these cohort members. These studies will include an evaluation of subjects' complete work histories and of possible confounding by such factors as smoking, country of birth, previous employment history and education. Therefore, the case-controls studies will provide more detailed information regarding the possible excess of lung and stomach cancer deaths found in this study.

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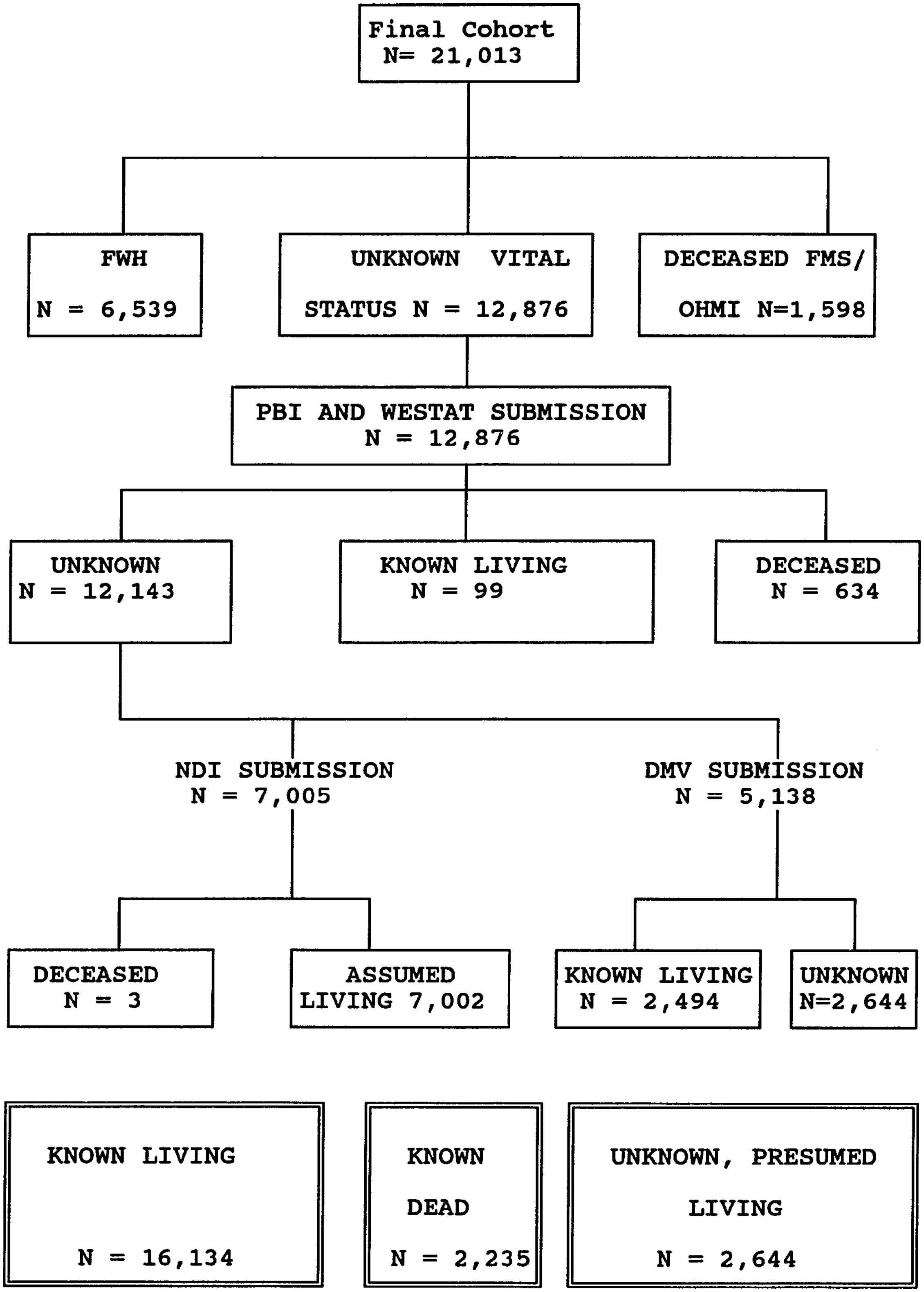

Figure 1: Vital Status Ascertainment

Table 1

Distribution of Subjects According to Race, Gender, Vital Status and Last Employment Status as of December 31, 1987

	Whites		Blacks	
	Male	Female	Male	Female
Total	14,758	1,461	4,012	782
Employment Status				
Active	4,732	312	1,288	193
Terminated	6,007	1,135	1,984	586
Retired	3,628	11	591	1
Deceased*	391	3	149	2
Vital Status				
Alive:	11,118	1,318	2,986	712
Deceased:	1,784	24	418	9
Cause of Death Known:	1,698	23	405	8
Cause of Death Unknown:	86	1	13	1
Unknown, Presumed Living	1,856	119	608	61

*Subjects who died while actively employed.

Table 2

Distribution of Subjects According to Other Selected Characteristics

	Whites		Blacks		Total	
	Male	Female	Male	Female	Male	Female
Total	14,758	1,461	4,012	782	18,770	2,243
Year of Hire						
1951-54	3,286	3	614	0	3,900	3
1955-59	2,300	1	444	0	2,744	1
1960-64	237	1	34	0	271	1
1965-69	1,399	1	857	2	2,256	3
1970-74	2,925	173	1,135	174	4,060	347
1975-79	4,599	1,282	923	606	5,522	1,888
≥ 1980	12	0	5	0	17	0
Length of Follow-up						
<5	449	7	104	1	553	8
5 - 9	1,609	512	406	229	2,015	741
10 - 14	5,274	877	1,277	503	5,551	1,380
15+	7,426	65	2,225	49	9,651	114
Duration of Employment						
<10	5,164	1,086	1,727	569	6,891	1,655
10 - 19	4,445	373	1,048	213	5,493	586
20+	5,149	2	1,237	0	6,386	2
Plant						
Foundry only	3,919	220	1,621	73	5,540	293
Engine only	5,331	534	1,180	279	6,511	813
Both Plants	4,662	704	1,211	430	5,873	1,134
Unknown	846	3	0	0	846	3

Table 3

Observed and Expected Number of Deaths and The SMRs With 95% Confidence Intervals for Selected Causes Among Women

ICD NO.	CAUSE OF DEATH	White OBS	White SMR	White 95% CI	Black OBS	Black SMR	Black 95% CI	Total OBS	Total SMR	Total 95% CI
ALL CAUSES		24	91	58- 135	9	46	21- 87	33	72	49- 101
140-209	ALL CANCER	6	62	23- 136	4	88	24- 227	10	73	35- 133
150-159	CANCER OF DIGESTIVE ORGANS	0	(1.5)	0- 245	1	121	2- 672	1	43	1- 239
151	STOMACH CANCER	0	(.17)	0-2190	0	(.14)	0-2533	0	(.31)	0-1190
160-163	RESPIRATORY CANCER	2	116	13- 421	1	158	2- 880	3	128	26- 373
162	LUNG CANCER	2	119	13- 431	1	166	2- 926	3	132	27- 385
174	BREAST CANCER	1	38	0- 212	1	82	1- 454	2	52	6- 188
390-458	ALL CIRCULATORY DISEASES	8	126	54- 248	2	38	4- 136	10	86	41- 158
460-519	ALL RESPIRATORY DISEASES	0	(1.1)	0- 324	0	(.87)	0- 422	0	(2.0)	0- 184
520-577	ALL DIGESTIVE DISEASES	0	(1.3)	0- 277	0	(1.4)	0- 257	0	(2.8)	0- 134
800-999	ALL EXTERNAL CAUSES OF DEATH	8	169	73- 333	1	28	0- 156	9	109	50- 206
800-949	ALL ACCIDENTS	2	74	8- 267	1	61	1- 341	3	70	14- 204
810-823	MOTOR VEHICLE ACCIDENTS	1	56	1- 310	1	122	2- 680	2	77	9- 279
950-959	SUICIDE	3	236	47- 690	0	(.36)	0-1019	3	184	38- 538
	RESIDUAL CAUSE KNOWN	1	31	0- 169				1	31	0- 169
	RESIDUAL CAUSE UNKNOWN	1	4.2%		1	11.1%		2	6.1%	

Expected number is displayed in bracket when observed number of deaths is zero.

Table 4

Observed and Expected Number of Deaths and The SMRs With 95% Confidence Intervals for Selected Causes Among Men

ICD NO.	CAUSE OF DEATH	White OBS	White SMR	White 95% CI	Black OBS	Black SMR	Black 95% CI	Total OBS	Total SMR	Total 95% CI
	ALL CAUSES	1784	97	93-102	418	80	73 - 88	2202	93	89- 97
140-209	ALL CANCER	426	98	89-107	129	117	98 -139	555	102	94-111
150-159	CANCER OF DIGESTIVE ORGANS	102	95	78-116	29	95	64 -136	131	95	79-113
151	STOMACH CANCER	24	158	101-234	4	73	20 -186	28	135	90-196
153	COLON CANCER	35	89	62-124	8	113	49 -223	43	93	67-125
157	PANCREATIC CANCER	20	92	56-141	10	187	89 -344	30	111	75-158
160-163	RESPIRATORY CANCER	179	108	93-125	53	126	94 -165	232	112	98-127
161	LARYNX	2	34	4-124	3	140	28 -409	5	62	20-145
162	LUNG CANCER	176	111	95-128	48	121	89 -161	224	113	99-129
185	PROSTATE CANCER	33	112	77-158	15	175	98 -288	48	126	93-167
188	BLADDER	11	100	50-179	3	211	42 -617	14	113	62-189
189	KIDNEY	14	129	70-216	1	54	1 -300	15	118	66-195
200-208	LYMPHATIC AND HEMATOPOIETIC	35	85	59-119	13	167	89 -285	48	98	72-130
200	LYMPHOSARCOMA AND RETICULOSARCOMA	9	152	69-288	0	(.81)	0 -450	9	134	61-254
201	HODGKIN'S DISEASE	5	162	52-378	2	334	38-1207	7	189	76-389
204-207	LEUKEMIA	12	74	38-130	5	173	56 -403	17	89	52-142
390-458	ALL CIRCULATORY DISEASES	803	95	88-101	133	72	61 - 86	936	91	85- 97
460-519	ALL RESPIRATORY DISEASES	85	70	56- 87	20	75	46 -116	105	71	58- 86
520-577	ALL DIGESTIVE DISEASES	78	101	80-126	14	50	27 - 83	92	87	70-107
800-999	ALL EXTERNAL CAUSES OF DEATH	193	95	82-109	84	82	66 -102	277	91	80-102
800-949	ALL ACCIDENTS	102	81	66- 99	31	67	45 - 95	133	77	65- 92
810-823	MOTOR VEHICLE ACCIDENTS	63	97	74-124	18	88	52 -138	81	95	75-118
950-959	SUICIDE	58	114	87-148	10	118	56 -217	68	114	89-145
	RESIDUAL CAUSE KNOWN	113	78	64- 93	25	36	23 - 53	138	64	54- 76
	RESIDUAL CAUSE UNKNOWN	86	4.8%		13	3.1%		99	4.5%	

Expected number is displayed in bracket when observed number of deaths is zero.

Table 5

Observed Stomach Cancer Deaths and SMRs Among White and Black Men According to Selected Characteristics

	White			Black			All Men		
Characteristics	OBS	US SMR	CC SMR	OBS	US SMR	CC SMR	OBS	US SMR	CC SMR
Year of Hire									
1950 - 54	18	198*	144	2	73	80	20	169*	133
1955 - 59	6	147	106	1	60	66	7	122	98
1960 - 64	0	(.27)	(.35)	0	(.04)	(.03)	0	(.31)	(.38)
≥ 1965	0	(1.8)	(2.4)	1	94	130	1	35	32
Year Since First Hire									
< 10	0	(1.0)	(1.3)	0	(.46)	(.36)	0	(1.5)	(1.7)
10 - 14	1	154	110	0	(.37)	(.29)	1	98	83
15 - 19	2	112	83	1	175	195	3	127	103
20+	21	178*	129	3	73	82	24	151	120
Duration of Employment									
< 15	2	52	38	0	(.93)	(.71)	2	42	33
15 - 19	6	157	113	1	125	133	7	151	115
20+	16	212*	156	3	80	90	19	168*	140

* Statistically significant at the 0.05 level.
Expected number is displayed in bracket when observed number of deaths is zero.

Table 6

Observed Lung Cancer Deaths and SMRs Among White and Black Men According to Selected Characteristics

	White			Black			All Men		
Characteristics	OBS	US SMR	CC SMR	OBS	US SMR	CC SMR	OBS	US SMR	CC SMR
Year of Hire									
1950 - 54	108	116	114	33	167*	132	141	125*	118
1955 - 59	44	100	100	11	91	72	55	98	93
1960 - 64	3	101	102	1	344	285	4	123	122
1965 - 69	10	182	188	1	26	22	11	118	112
≥ 1970	11	84	87	2	56	47	13	79	77
Year Since First Hire									
< 10	5	50	51	2	70	58	7	54	53
10 - 14	11	163	169	1	38	31	12	128	123
15 - 19	11	67	69	3	77	61	14	69	67
20+	149	119	117	42	139*	111	191	123*	116*
Duration of Employment									
< 10	11	83	85	2	48	40	13	75	72
10 - 14	17	85	81	1	47	39	18	81	76
15 - 19	35	95	94	7	138	107	42	100	96
20+	113	127*	128*	38	135	107	151	129*	122*

* Statistically significant at the 0.05 level.

Table 7

Distribution of Selected Causes of Death and The SMRs Among Men Employed Only In The Foundry (N=5,540), Only in The Engine Plants (N=6,511) and in Both Foundry and Engine Plants (N=5,873) Since 1973

	Whites			Blacks			Total		
	OBS	SMR	95% CI	OBS	SMR	95% CI	OBS	SMR	95% CI
Foundry	(N=3,919)			(N=1,621)			(N=5,540)		
All Causes	426	98	89-108	204	86	74- 98	630	94	87-101
All Cancer	107	99	81-120	59	114	87-147	166	104	89-121
Stomach Cancer	5	138	45-323	2	77	9-277	7	113	45-232
Pancreatic Cancer	4	74	20-191	2	79	9-285	6	76	28-165
Lung Cancer	49	119	88-157	23	124	78-186	72	121	94-152
Prostate Cancer	5	93	30-217	10	234	112-430	15	155	87-256
Respiratory disease	18	72	43-114	12	97	50-169	30	80	54-114
External Causes	65	118	91-151	41	94	68-128	106	108	88-130
Motor Vehicle Accidents	24	137	88-204	7	80	32-369	31	118	80-168
Suicide	20	144	88-222	6	170	62-369	26	149	98-219
Engine Plant	(N=5,331)			(N=1,180)			(N=6,511)		
All Causes	643	94	87-102	159	81	69- 95	802	91	85- 98
All Cancer	178	101	87-118	60	129	98-166	238	107	94-121
Stomach Cancer	15	254	142-420	2	85	10-306	17	206	120-331
Pancreatic Cancer	8	91	39-179	7	303	121-624	15	135	76-223
Lung Cancer	81	120	95-149	23	135	85-202	104	123	101-149
Prostate Cancer	8	87	37-170	5	129	41-300	13	99	53-170
Respiratory disease	22	53	33- 80	6	57	21-123	28	54	36- 77
External Causes	56	80	61-104	29	106	71-153	85	87	70-108
Motor Vehicle Accidents	17	80	46-127	10	179	86-329	27	100	66-145
Suicide	18	99	59-156	2	92	10-331	20	98	60-152

Table 7
(Continued)

Distribution of Selected Causes of Death and The SMRs Among Men Employed Only In The Foundry (N=5,540), Only in The Engine Plants (N=6,511) and in Both Foundry and Engine Plants (N=5,873) Since 1973

	Whites			Blacks			Total		
	OBS	SMR	95% CI	OBS	SMR	95% CI	OBS	SMR	95% CI
Foundry And Engine Plant	(N=4,662)			(N=1,211)			(N=5,873)		
All Causes	168	81	69- 95	55	64	48- 83	223	76	66- 87
All Cancer	37	91	64-125	10	86	41-158	47	90	66-119
Stomach Cancer	0	(1.3)	00-285	0	(.54)	0-676	0	(1.8)	00-202
Pancreatic Cancer	0	(1.8)	00-200	1	198	3-1102	1	43	1-239
Lung Cancer	17	122	71-195	2	52	6-186	19	107	64-166
Prostate Cancer	3	267	54-780	0	(.41)	0-884	3	196	40-573
Respiratory disease	3	39	8-114	2	56	6-202	5	44	14-104
External Causes	61	95	73-122	14	44	24- 75	75	79	62- 98
Motor Vehicle Accidents	18	78	46-124	1	16	00- 89	19	65	39-102
Suicide	18	121	72-191	2	72	8-261	20	113	69-175

Expected number is displayed in bracket when observed number of deaths is zero.

Table 8

Distribution of Selected Causes of Death and the Relative Rates (RR) for Male Workers, by Work Area Within the Foundry Since 1973

	Cause of Death					
	All cancers		Lung Cancer		Stomach Cancer	
Work Area	OBS	RR	OBS	RR	OBS	RR
Molding	45	0.71	16	0.60	2	0.67
Core Room	65	1.16	27	1.51	2	0.69
Melting	18	0.98	5	0.89	1	1.10
Finishing	50	0.93	19	0.89	2	0.82
Pattern Shop	10	0.88	5	0.94	1	1.37
Maintenance	72	0.96	29	0.88	2	0.43
Material Handling	22	1.55*	12	2.03*	1	1.47
Administration	11	1.31	6	1.70	0	0.00

RR was computed from Poisson regression models and are adjusted for age, calendar time, and race.

*Statistically significant at the 0.05 level.

Table 9

Distribution of Selected Causes of Death and the Relative Rates (RR) for Male Workers, by Work Area Within the Engine Plants Since 1973

	Cause of Death					
	All cancers		Lung Cancer		Stomach Cancer	
Work Area	OBS	RR	OBS	RR	OBS	RR
Machining	102	0.92	38	0.76	6	1.09
Assembly	92	1.05	43	1.23	6	1.54
Maintenance	71	0.93	27	0.76	4	0.92
Packaging	35	1.44*	14	1.31	2	1.62
Administration	32	0.60	17	0.71	3	1.73

RR was computed from Poisson regression models and are adjusted for age, calendar time, and race.

*Statistically significant at the 0.05 level.

Appendix A

Observed and Expected Number of Deaths and SMR's for Selected Causes of Death According to Two Methods of Accumulating Person-Years for Cohort Members with Unknown Vital Status

	Uncensored[1]			Censored[2]	
Causes of Death	Obs.	Exp.	SMR	Exp.	SMR
All Causes	2202	2353.2	94	2249.1	98
All Cancer	555	546.1	102	527.1	105
Lung Cancer	224	198.4	113	192.0	117
Stomach Cancer	28	20.7	135	20.1	139

[1]Terminated employees with unknown vital status are assumed alive at the end of follow-up.

[2]Terminated employees with unknown vital status are censored from follow-up at their termination date.

PART II

NESTED CASE-CONTROL STUDY OF STOMACH CANCER

Part II of this study is a case-control study of stomach cancer among employees of the Ford Motor Company plants at the Brook Park (BP) Complex in Cleveland, Ohio. The study evaluates further the relation between stomach cancer and BP employment factors.

Background

The RFS indicated that white cohort members had an elevated stomach cancer rate. The SMRs for white men, black men, and all men were 158 (CI=101-234), 73 (CI=20-186) and 135 (CI=90-196) respectively. The excess mortality from stomach cancer was concentrated among men who were first employed before 1960 (SMR=153; CI=101-223), who had 20 or more years of employment (SMR=168; CI=101-262) and who had worked in the engine plants as opposed to the foundry. The excess of stomach cancer deaths could not be explained entirely by geographic variation in rates. This is so because the excess persisted in certain subgroups when the cohort was compared to the population of Cuyahoga County (CC), where the plants are located.

Because of incomplete work histories, the RFS was not able to evaluate thoroughly specific departments or jobs that may have been associated with stomach cancer mortality rates. Also, the excess stomach cancer mortality could have been due to confounding, if subjects in the plants, jobs, or departments found to be associated with excess deaths from stomach cancer were disproportionately from areas of the world (e.g., Eastern Europe) associated with an increased risk of stomach cancer or had been exposed to stomach carcinogens at work places before and after employment at the index plants.

The purpose of the present study is to examine further the relationship between stomach cancer and occupational factors at the BP by obtaining and evaluating the complete work histories of cases and controls. The study also includes an assessment of the possible confounding effects of variables such as country of birth, smoking status and previous occupational exposures to stomach carcinogens.

Methods

Subjects

The stomach cancer cases are those cohort members who died during the follow-up period (January 1, 1970, to December 31, 1987) and whose death certificate indicated stomach cancer as an underlying or secondary cause of death. Four controls were selected from among all cohort members for each stomach cancer decedent. The controls were individually matched to each case according to race, gender and year of birth. Also, the controls for a case were required to be alive and under observation on the death date of the case. When more than four subjects were eligible to serve as a control for a specific case, four were chosen at random. To ensure that the incidence density rate ratio (RR) would be estimated by the exposure odds ratio (EOR), each subject was eligible to be selected as a control for all cases with whom he "matched". Also, a case was eligible to serve as a control until his death. This control selection procedure is referred to as "density sampling" (1,2).

Data Sources

Work Histories

The complete work histories of all cases and controls were obtained from plant personnel files. The work histories were coded by an individual who was unaware of the case-control status of subjects, in order to avoid observer bias (Appendix A). The personnel records contained some demographic data and a chronological listing of all jobs, departments, and BP plants at which an employee ever worked. The coded work history records were then converted into a computer file, which was used to classify subjects as ever versus never having worked in: (1) a particular plant (foundry, engine plant 1 or engine plant 2); (2) specific jobs and departments within the plants; (3) major areas within the plants such as molding, core room, melting, finishing/cleaning, maintenance, pattern shop, material handling and administration in the foundry and machining, assembly, maintenance, packaging, stamping and administration in the engine plants.

An attempt was made to obtain an industrial hygiene (IH) assessment of exposures at the three plants that could be linked to subjects' work histories. The substances of potential interest were polycyclic aromatic hydrocarbons (PAHs), cutting fluids (straight oils, soluble oils, semi-synthetic and synthetic fluids), silica, aldehydes (especially formaldehyde), metal dust and asbestos. The scope of this study did not include an indepth IH survey of the plants; hence, all exposure data were obtained from pre-existing IH records maintained by the plants and the local union. These IH data were of unknown quality and were incomplete. Exposure information was available for some years for silica, formaldehyde, asbestos, cutting fluids, total particulates and PAHs. Evaluation of the IH data revealed that only the data available for the cutting fluids used in engine plant 1 were complete enough for further consideration. Information on type of cutting fluids was obtained from plant material fact sheets and from material specification sheets. The department/year exposure matrix that was developed for the other contaminants was too incomplete for a meaningful analysis.

Questionnaire Data

Information was obtained on potential confounding variables (e.g., country of birth, smoking habit and employment history) by interviewing living controls and the next-of-kin of the deceased cases and controls, using a structured questionnaire (Appendix B). The interviewing was completed between November, 1989, and November, 1990. All respondents were interviewed by telephone.

Subjects were classified according to three major country of birth categories: United States, Eastern Europe and other foreign countries. Using the smoking information from the questionnaire, subjects were classified as never smokers, ex-smokers, and current smokers of cigarettes, cigars and/or pipes. Also, subjects were classified as "never", "light" or "heavy" smokers based on the average number of cigarettes or cigars or pipes smoked per day over a subject's lifetime, if a case, and, if a control, over the period of time up to the death date of the matching case. A case was considered an ex-smoker if he had stopped smoking at least 5 years before his date of death. A control was considered an ex-smoker if he had stopped smoking at least 5 years before the death date of his case.

Subjects were classified according to high-risk employment before and after working at the BP Complex. Industries and occupations that may entail exposure to stomach carcinogens were specified on the basis of a literature review (3). Appendix B contains a list of the industries and occupations considered high-risk in this study.

<u>Data Analysis</u>

The main objective of the data analysis was to evaluate the relationship between stomach cancer and work areas and potential exposure to cutting fluids, while adjusting for confounding variables. The measure of association is the EOR, which provides an estimate of the RR, i.e., the ratio of the mortality rate among exposed subjects to the mortality rate among unexposed subjects. Conditional logistic regression models were used to obtain the maximum likelihood estimates of the RRs for working in a particular plant (yes versus no), department or job or for exposure to cutting fluids. Trend analyses were based on total months of employment in a work area, department or job or in jobs involving potential exposure to cutting fluids. These analyses were performed using less than 10 years and 10 plus years cut-points for duration of employment, as well as a continuous evaluation.

The RRs were computed with and without adjustment for possible confounding variables. Factors evaluated as confounders included country of birth of the subject, country of birth of the parents, smoking habits, total years of schooling and high-risk employment before or subsequent to working at the BP Complex. Of these factors, only country of birth proved to be associated with stomach cancer and, therefore, was included in all analyses that showed a statistically significant departure from the null value of 1.0. If adjustment for country of birth appreciably modified the direction or strength of an apparent association, it was kept in the analyses. Because we were able to obtain all work history information for the cases and controls, subject exclusions occurred only when using information from the questionnaire.

The 95% confidence intervals (CI) were computed for each RR estimate. An RR is designated as statistically significant if the P-value is less than 5% and the 95% CI does not include the null value of 1.0.

Results

A total of 30 stomach cancer cases and 116 controls were included in the study. Twenty-eight of the 30 cases had a set of 4 controls with complete work history records. One case had only one control because the BP work history records for 3 of the 4 controls selected for this case could not be obtained. Another case had 3 controls because it became apparent after the control selection that one of his controls had died before he had. We interviewed and obtained information on possible confounding factors for a total of 23 (77%) cases and 79 of (68%) controls.

A total of 61%, 22% and 17% of the interview data for the cases came from their spouses, children and other sources, respectively. For the controls, 53%, 10%, 11% and 5% of the interview data were obtained from the living subjects (self), spouses, children and other sources, respectively.

Table 1 describes the general characteristics of cases and controls. Twenty-five (83%) of the 30 cases and 92 (79%) of the controls are White, whereas 5(17%) of the cases and 24 (21%) of the controls are Black. Cases and controls have similar year of birth, with a median of 1919. The cases and controls differ markedly with respect to vital status. Only 15% of the controls are deceased, as opposed to all of the cases at the end of the follow-up period. The mean age at death of the cases was 66 years. Cases and controls are similar with respect to their hire date. The median hire year is 1954 for the cases and 1953 for the controls. About 60% of the cases and 75% of the controls had retired from the index plants. The average durations of employment for the cases and for the controls at BP are 23 and 22 years, respectively, suggesting that the cases were employed slightly longer than the controls.

A higher proportion of cases than controls were first or second generation immigrants (table 2). Birth in Eastern Europe as opposed to the United States is positively associated with stomach cancer mortality, with an RR of 1.68 (CI=0.40-7.02) if the subject is born in Eastern Europe; an RR of 6.49 (CI=1.23-34.18) for birth of the subject's father in Eastern Europe; and an RR of 3.92 (CI=0.75-20.48) for birth of the subject's mother in Eastern Europe. The RR for the subject or either parent's having been born in Eastern Europe is 5.25 (CI=0.97-

28.44). The RRs for other foreign and for any foreign country of origin also are elevated.

There is no evidence of an association between cigarette smoking and stomach cancer mortality (table 3). There is no dose-response relation with average number of cigarettes smoked per day. Results are similarly null for cigar and pipe smoking.

The risk of dying from stomach cancer decreases with increasing total years of schooling (table 4). However, the observed protective effect of total years of schooling is not statistically significant, nor is it consistent. Cases and controls have similar industrial and occupational exposure histories (table 4). The RR for employment in industries considered to be associated with a high risk of stomach cancer is 1.13 (CI:0.39-3.30). Cases tend to be less exposed to potential occupational stomach carcinogens than controls (RR=0.13, CI:0.03-0.62). However, this finding may reflect the superior interview data for controls. As mentioned earlier, 67% of the interview data for controls as opposed to 0% for the cases were self-reported.

Subjects who were hired in the 1950s experienced a more than three-fold increased mortality rate from stomach cancer when compared with subjects hired in the 1960s or later (table 5). Also, subjects who were employed for 25 years or more experienced a more than three-fold increased rate of stomach cancer mortality, and subjects who were employed for 15-24 years experienced about a two-fold increased rate compared to subjects who were employed for fewer than 15 years. Adjusting for Eastern European birth did not have any significant impact on these RRs. Therefore, only the unadjusted RRs are reported.

Job Group

The distribution of cases and controls according to job group (job family codes) is displayed in table 6. The RRs are elevated for assemblers (RR=1.46), non-production inspectors (RR=1.57), maintenance jobs (RR=2.21), grinders (RR=1.52) and in-line machine operators (RR=1.19). None of these RRs is statistically significant.

Departments

The distributions of cases and controls according to departments in the foundry, in engine plant 1 and in engine plant 2 are displayed in tables 7, 8 and 9, respectively. In the foundry, the estimated RR is elevated for maintenance/environmental control (RR=1.41), environmental control (RR=2.01), core room (RR=1.43) and cleaning departments (RR=1.58). None of these RRs is statistically significant, indicating a general lack of association between stomach cancer mortality and work in the foundry.

In engine plant 1, the RR is elevated for packaging/shipping, maintenance, crankshaft machining, assembly/unspecified, engine assembly/hot testing and stamping. Only the findings pertaining to general maintenance (P=0.06) and assembly (P=0.06) approach statistical significance. Unlike the foundry and engine plant 1, departments in engine plant 2 displayed more consistent positive associations with increased stomach cancer mortality. However, only the RR for packaging/shipping is statistically significant (P=0.03).

<u>Department Group</u>

The departments that were evaluated in the foundry and in the engine plants were grouped according to type of processes. This was an attempt to identify the work areas within these plants that may entail a high risk of stomach cancer. As can be seen in table 10, the RR for certain work areas within the foundry is elevated: core making (RR=1.40; CI=0.50-3.88), melting (RR=1.67; CI=0.30-9.39) and maintenance (RR=1.14; CI=0.44-2.93). The RRs for the following work areas within the engine plant 1 (table 11) are elevated: packaging (RR=1.87; CI=0.62- 5.68), stamping (RR=1.68; CI=0.36-7.83) and administration (RR=1.10; CI=0.28-4.28). Unlike the foundry and engine plant 1, all but one work area (maintenance, RR=0.85) within engine plant 2 displayed a positive association with stomach cancer mortality. The more than two-fold increased stomach cancer mortality rate for subjects working in the machining area of engine plant 2 is statistically significant (P=0.04). However, there is no clear dose-response relation between duration in the machining work areas and stomach cancer mortality. A further breakdown of the machining area of engine plant 2 according to the type of material machined showed elevated RRs for the machining of cast iron (RR=2.57) and aluminum (RR=1.27). The RR for steel machining is below unity. The RR pertaining to the machining of cast iron is statistically significant, as is the positive trend (P=0.04). Adjustment for Eastern European birth does not meaningfully alter these results.

Plant

Working in engine plants 1 or 2 is associated with a small excess of stomach cancer deaths (table 12). Although the RR for working in engine plant 2 (RR=1.26) is small and is not statistically significant, a positive trend (P=0.04) is present for increasing duration of employment. Subjects who worked for more than 10 years at engine plant 2 have a more than two-fold increased risk of stomach cancer compared to subjects who were never employed in the plant. The RR for subjects employed for less than 10 years is approximately equal to the null value of 1.0.

Subjects who worked only in engine plant 1 or 2, compared with those who worked only in the foundry, have an RR of 2.89. However, the elevated RR is not statistically significant.

Cutting Fluids

The distribution of cases and controls according to type of cutting fluids used in the various machining processes in engine plant 1 is displayed in table 13. There is no positive association between machining with any specific type of cutting fluid and stomach cancer.

Discussion

The major methodologic strengths of this study derive from the subject selection procedures and from the objectivity of available data on work history and on potential confounders, especially country of birth of the study subjects and of their parents. Cases included all cohort members whose death certificate indicated stomach cancer as the underlying or a contributory cause of death. Controls were selected randomly from among all cohort members who were of the same race, gender and age as the respective cases and who were alive and under observation as of the death date of the cases. These selection procedures reduce the possibility of selection bias and enhance adjustment for confounding by age, race, gender and calendar time. Also, differential information bias is minimized in this study because all BP work histories were obtained from existing personnel records and were abstracted and coded "blind".

The most important limitations of the study is its small size. The study included only 30 stomach cancer cases. The problem of small size was further compounded by our inability to interview all the study subjects or their next-of-kin. Also, about 70% of interviews for controls was self-reported as opposed to 0% for the cases. The implication is that the data available on potential confounders are likely to be more accurate for the controls than for the cases. This was apparent in the analysis pertaining to employment histories before and after working at the index plants. Controls tended to be more exposed to high risk occupations than cases. The most important implication of this lack of comparability of some interview data for cases and controls is that potential confounders may not have been completely controlled for in this study.

A particularly interesting finding of this study is the unusually high proportion (about 10%) of study subjects who were born in Eastern Europe. Persons in Eastern Europe have been reported to have high incidence of stomach cancer (4,5). Also, Eastern European immigrants living in the United States have been reported to have a two-fold risk of dying from stomach cancer compared to the native-born (6,7). If BP cohort members were more likely to be of Eastern European origin than the general population of the US, to which they were compared in the RFS, then some of the excess stomach cancer deaths observed in that study may have been due to confounding by foreign birth. This possibility is suggested by the fact that in the RFS excess of stomach cancer deaths decreased when the cohort was compared to the general population of the county in which the BP plants are located, as opposed to that of the United States.

Eastern European birth did not appear to confound the findings of the case-control study because subjects born in Eastern Europe apparently were not selectively assigned to jobs in the BP plants. As stated previously, we collected data on other potential confounders. These included total years of schooling, employment histories before and after working at the index plants and smoking habits. However, these factors were not determinants of stomach cancer in this study and, therefore, were not confounders.

The elevated RR for stomach cancer among men who were first employed in the 1950s as opposed to the 1960s or later is consistent with the findings of the RFS. This result suggests that men who were employed in the 1950s (when the plants first commenced operations) were exposed to stomach carcinogens. However, chance and confounding are possible alternative explanations. This is so because the confidence intervals for the elevated RRs included the null value of 1.0, and residual confounding by country of birth is possible because we were unable to obtain this information for all subjects.

Material handlers and grinders had elevated RRs. The finding pertaining to material handlers displayed a dose-response relation between total years of employment and stomach cancer risk. However, this association was unexpected and is not supported by the results of previous epidemiologic studies. Interviews with members of the local union and with Ford management indicate that a high proportion of workers in material handling departments have acquired 10 or more years of seniority in other areas (e.g., machining and assembly) before bidding for a job as a material handler, an obviously less strenuous occupation. Therefore, we may be observing the effect of what may be termed "selective transfer" from high risk jobs to low risk jobs after experiencing adequate amount of exposure to potential hazardous substances to initiate carcinogenesis. The finding of an elevated stomach cancer RR among grinders in both the RFS and this case-control study is supported by the results of previous epidemiologic studies (8,9). Furthermore, there seems to exist a biologically plausible mechanism by which persons who are exposed to substances such as abrasive dusts and oil mist, which may contain nitrosamines and PAHs, may develop stomach cancer (10).

Results of the analysis evaluating the possible association between stomach cancer and employment in engine plant 1 were inconsistent. On the other hand, Engine plant 2 displayed a small positive association with stomach cancer risk. This association displayed a positive dose-response with increasing years of total employment. All major sections (with the notable exception of the maintenance departments) within this engine plant displayed positive association with stomach cancer risk. Only the association pertaining to the machining area was statistically significant. A further analysis of the machining section by type of material machined revealed that most of the excess stomach cancer deaths in this section occurred among men who machined cast iron products. The more than two-fold increased risk was statistically significant. Machining of cast iron also displayed a positive dose-response relation. The consistency and lack of confounding by country of birth of these findings suggest the presence of some stomach carcinogens in engine plant 2.

The analysis by type of cutting fluids in engine plant 1 (soluble oil, insoluble oil, semi-synthetic and synthetic fluids) did not implicate any type of cutting fluids. The observed deaths were just about what would be expected among men who performed operations that entailed exposure to one or some combination of these cutting fluids. Similar industrial hygiene data were not available for the engine plant 2 where we found more consistent association between stomach cancer and engine plant exposure. The results pertaining to cutting fluids should therefore be interpreted with caution.

The finding that the excess of stomach cancer was concentrated among engine plant workers in this case-control study is of particular interest. It is consistent with the results of the RFS and of previous epidemiologic investigations (8,9,11-19) and with experimental data demonstrating the carcinogenic potential of certain cutting fluids which were present in many of the BP work areas (20,21). In a study of automobile engine plant workers, Vena and associates (12) reported significant proportional excess of gastrointestinal cancer (PMR=190) among workers with more than 20 years of employment. The excess was attributed to exposure to oil mist generated during grinding and spray lubricating. Decoufle (1978) reported a statistically significant two-fold excess of cancer of the stomach and large intestine among workers with at least 20 years of latency in machining jobs that entailed exposure to both insoluble and soluble oils (13). Dubrow and Wegman, in a study based on death certificates, reported positive association between stomach cancer and work as machinists exposed to any type of cutting fluids in Massachusetts (11). Silverstein et al. reported a PMR of 339 for stomach cancer among white men with more than 10 years of exposure to metal working fluids in a bearing plant and attributed this association to grinding operations using water-based cutting fluids (8). In a similar PMR study of bearing plant workers, Park and coinvestigators reported a PMR of 200 and attributed the excess to precision grinding done predominantly with water-based cutting fluids (9). Jarvholm also reported an increased gastrointestinal cancer (9 observed vs. 6.6 expected) among grinders with at least 5 years employment and at least 20 years of latency in operations that entailed exposure to cutting fluids (17). On the other hand, several epidemiologic studies have found no association between exposure to oil mists and stomach cancer (22-24).

The roles of several non-occupation factors in the etiology of stomach cancer have been well documented. These factors include diet, socioeconomic status, smoking, country of birth and genetic factors. Overall the diet studies suggest that a high intake of complex carbohydrates, salted and smoked foods may be important in the etiology of stomach cancer. However, the most consistent finding in studies of diet and stomach cancer has been the negative association of stomach cancer with the intake of fresh fruits and vegetables (4,25).

The possible confounding effect of diet was not evaluated directly in this study. However, our finding of positive association between Eastern European birth and increased risk for stomach cancer supports the findings of several other epidemiologic studies (6,7,26,27). Total years of schooling (a good indicator of socio-economic status) was negatively associated with increased risk for stomach cancer. Meaning, stomach cancer risk decreases with increasing years of schooling. However, this protective effect was not statistically significant. Several other international studies have reported consistent association between stomach cancer and low socio-economic status (28-30). Smoking was not associated with stomach cancer in this study. A Similar lack of association between smoking and stomach cancer has been reported in previous epidemiologic studies (31,32-34). However several other previous epidemiologic studies have reported a positive association between smoking and stomach cancer (29,35-38). The general lack of dose-response relationship (with the notable exception of the case-control study by Wu-Williams et al., 1990) in the above cited positive studies seems to indicate chance findings rather than causal.

The findings of this case-control study are inconsistent, but because of small numbers, and some of the positive findings in engine plant 2, we cannot exclude an increased risk for cancer of the stomach among BP workers. Of particular importance is the rather consistent and statistically significant finding of increased risk of stomach cancer deaths among machinists (especially among grinders and men who machined cast iron products) in engine plant 2. Furthermore, the finding of excess stomach cancer in the RFS among men who were first employed in the 1950s as opposed to the 1960s or later and among men ever employed in the engine plants is supported by similar results in this case-control study.

Conclusions

The findings of both the RFS and the case-control study indicate an apparent excess of stomach cancer at these plants. This excess appears to be related to some exposure(s) in the engine plants as opposed to the foundry. The studies failed to implicate strongly and consistently any work areas as responsible for the increased risk of stomach cancer. However, specific processes such as machining (especially, grinding of cast iron) and packaging/shipping were implicated in the engine plants. The generally weak or null associations in the case-control study, may be due to the ubiquitous nature of exposure(s) in these plants and the small study size.

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Table 1

General Characteristics of Stomach Cancer Cases And Controls.

	No. of Subjects	
	Cases	Controls
Total	30 (100%)	116 (100%)
Race:		
White	25 (83)	92 (79)
Black	5 (17)	24 (21)
Year of Birth:		
≤ 1910	6 (20)	21 (18)
1911 - 1920	15 (50)	60 (52)
1921 - 1930	9 (30)	35 (30)
Vital Status:		
Alive	0 (0)	79 (68)
Deceased	30 (100)	17 (15)
Assumed Living	0 (0)	20 (17)
Year of Hire:		
1950 - 1954	22 (73)	78 (68)
1955 - 1959	7 (23)	26 (22)
1960 - 1969	1 (3)	7 (6)
1970 - 1979	0 (0)	5 (4)
Last Employment Status:		
Active	5 (17)	8 (7)
Retired	18 (60)	87 (75)
Terminated	7 (23)	21 (18)
Duration of Employment(yrs):		
≤ 9	0 (0)	8 (7)
10 - 19	9 (30)	34 (29)
20+	21 (70)	74 (64)

Table 2

Distribution of Cases and Controls, And of Their Parents, The Matched Rate Ratio With 95% Confidence Intervals According to Place of Birth

	No. of subjects			
	Cases	Controls	RR	95% CI
Total	30(100%)	116(100%)		
Subject				
USA	16 (53)	59 (51)	1.00	
Eastern Europe	4 (13)	9 (8)	1.68	0.40,7.02
Other country	3 (10)	11 (9)	0.72	0.13,4.15
Unknown	7 (23)	37 (32)		
Father				
USA	6 (20)	50 (43)	1.00	
Eastern Europe	7 (23)	12 (10)	6.49	1.23,34.18
Other country	8 (27)	14 (12)	9.14	1.65,50.71
Unknown	9 (30)	40 (35)		
Mother				
USA	7 (23)	47 (40)	1.00	
Eastern Europe	6 (20)	14 (12)	3.92	0.75,20.48
Other country	8 (27)	16 (14)	7.24	1.30,40.21
Unknown	9 (30)	39 (34)		
Subject or either parent				
USA	6 (20)	47 (40)	1.00	
Eastern Europe	7 (23)	14 (12)	5.25	0.97,28.44
Other country	8 (27)	16 (14)	7.64	1.41,41.30
Unknown	9 (30)	39 (34)		

Table 3

Distribution of Cases And Controls, The Matched Rate Ratio With 95% Confidence Intervals According to Smoking habits

	No. of subjects			
	Cases	Controls	RR	95% CI
Total	30(100%)	116(100%)		
Cigarette				
Never Smoked	4 (13)	20 (17)	1.00	
Ex-Smoker	9 (30)	29 (25)	1.01	0.22,4.52
Current Smoker	10 (33)	30 (26)	1.11	0.27,4.59
Unknown	7 (23)	37 (32)		
Cigar				
Never Smoked	19 (63)	63 (54)	1.00	
Ex-Smoker	3 (10)	8 (7)	1.38	0.29,6.62
Current Smoker	1 (13)	8 (7)	0.35	0.04,3.13
Unknown	7 (23)	37 (32)		
Pipe				
Never Smoked	20 (67)	59 (51)	1.00	
Ex-Smoker	1 (3)	14 (12)	0.22	0.02,1.85
Current Smoker	2 (7)	6 (5)	1.33	0.21,8.36
Unknown	7 (23)	37 (32)		

Table 4

Distribution of Cases And Controls, The Matched Rate Ratio With 95% Confidence Intervals According To Total Years of Schooling, Previous "High Risk" Industries And Occupational Exposures

	No. of subjects			
	Cases	Controls	RR	95% CI
Total	30(100%)	116(100%)		
Years of Schooling:				
0 - 6	5 (17)	11 (9)	1.00	
7 - 12	12 (40)	59 (51)	0.33	0.07,1.53
13+	2 (7)	6 (5)	0.51	0.06,4.49
Unknown	11 (36)	40 (35)		
*Industry:				
No	12 (40)	39 (33)	1.00	
Yes	11 (37)	40 (35)	1.13	0.39,3.30
Unknown	7 (23)	37 (32)		
*Exposure:				
No	19 (63)	40 (35)	1.00	
Yes	4 (13)	39 (33)	0.13	0.03,0.62
Unknown	7 (23)	37 (32)		

*Industries and Occupational exposures suggested to be associated with increased risk of stomach cancer (see appendix B).

Table 5

Distribution of Cases and Controls, The Matched Rate Ratios with 95% confidence Intervals According to Employment Characteristics at Index Plants

	No. of subjects			
	Cases	Controls	RR	95% CI
Total	30(100%)	116(100%)		
Year of Hire:				
≥1960	1(3)	13 (11)	1.00	
1955-59	7(23)	26 (22)	3.50	0.39,30.8
1950-54	22(73)	77 (66)	3.60	0.44,29.3
Years Worked:				
<15	3(10)	20 (17)	1.00	
15-24	11(37)	46 (40)	2.10	0.42,10.4
≥25	16(53)	50(43)	3.40	0.66,17.8

Table 6

Distribution of Cases and Controls, the Matched Rate Ratio with 95% Confidence Intervals According to Job Group

	No. of subjects			
	Cases	Controls	RR	95% CI
Total	30(100%)	116(100%)		
Job Group:				
Assembly	18(60)	59(51)	1.46	0.65,3.30
Prod. inspector	3(10)	20(17)	0.57	0.16,2.00
Non Prod. Inspector	6(20)	16(14)	1.57	0.57,4.30
Core & Mold	10(33)	43(37)	0.88	0.37,2.00
Cleaners	8(27)	45(39)	0.54	0.21,1.40
Maint. & Construction	6(20)	13(11)	2.21	0.71,6.90
Material Handling	10(33)	40(35)	0.98	0.43,2.20
Prod. Repair	3(10)	11(10)	0.96	0.26,3.50
Vehicle Operator	2(7)	10(9)	0.78	0.16,3.60
Burring	4(13)	17(15)	0.90	0.29,2.80
Grinders	7(23)	20(17)	1.52	0.56,4.10
In-line Machine operators	3(10)	10(9)	1.19	0.31,4.60
Milling	2(7)	10(9)	0.77	0.16,3.70

Table 7

Distribution of Cases and Controls, the Matched Rate Ratio with 95% Confidence Intervals According to Departments in the Foundry

	No. of subjects			
	Cases	Controls	RR	95% CI
Total	30(100%)	116(100%)		
Departments:				
Stock Preparation	1(3)	7(6)	0.53	0.60,4.52
Maintenance/ Env. Control	6(20)	18(16)	1.41	0.50,4.04
Environmental Control	5(17)	11(10)	2.01	0.63,6.37
Melting	1(3)	4(3)	1.00	0.11,8.95
Molding(Small Parts)	4(13)	17(15)	0.93	0.28,3.05
Molding (Blocks)	2(7)	11(10)	0.57	0.12,2.78
Core Room	5(17)	15(13)	1.43	0.45,4.51
Cleaning	5(17)	13(11)	1.58	0.53,4.72

Table 8

Distribution of Cases and Controls, the Matched Rate Ratio with 95% Confidence Intervals According to Departments in the Engine Plant 1

	No. of subjects			
	Cases	Controls	RR	95% CI
Total	30(100%)	116(100%)		
Departments:				
Packaging/Shipping	3(10)	3(3)	4.00	0.81,19.8
General Maintenance	2(7)	10(9)	0.77	0.15,3.9
Maintenance	3(10)	2(2)	6.00	1.0,35.9
Small Parts Machining	2(7)	13(11)	0.59	0.13,2.7
Unknown	3(10)	10(9)	1.20	0.30,4.7
Cylinder Heads	2(7)	11(10)	0.68	0.13,3.1
Cylinder Block 8	2(7)	13(11)	0.59	0.13,2.7
Crankshaft	3(10)	6(5)	2.03	0.48,8.6
Machining (302)	4(13)	15(13)	1.07	0.35,3.2
Hot Testing 8	7(23)	29(25)	0.89	0.34,2.2
Engine Shipping/ Hot Testing	2(7)	12(10)	0.64	0.14,3.0
Assembly Unspecified	5(17)	6(5)	3.20	0.90,11.3
Assembly engine/ Hot Testing	6(20)	12(10)	2.14	0.68,6.7
Stamping	3(10)	8(7)	1.68	0.36,7.8

Table 9

Distribution of Cases and Controls, the Matched Rate Ratio with 95% Confidence Intervals According to Departments in the Engine Plant 2

	No. of subjects			
	Cases	Controls	RR	95% CI
Total	30(100%)	116(100%)		
Departments:				
Quality Control	4(13)	9(8)	1.96	0.54, 7.17
Packing/Shipping	3(10)	1(1)	12.00	1.25,115.38
Cylinder Head	3(10)	3(3)	4.00	0.81, 19.80
Flywheel, Housings, & Cyl. Heads	1(3)	11(10)	0.34	0.04, 2.75
Oil Pump, 300 & 302	3(10)	10(9)	1.18	0.32, 4.41
351 Crankshaft	4(13)	6(5)	2.78	0.74, 10.51
Piston 6 & Conn. Rod	3(10)	10(9)	1.22	0.32, 4.71
302 Conn. Rod	4(13)	13(11)	1.22	0.38, 3.91
351 Manufacturing Comp.	8(27)	27(23)	1.14	0.48, 2.73
Unspecified Assembly	4(13)	14(12)	1.14	0.35, 3.04

Table 10

Distribution of Cases and Controls, the Matched Rate Ratio with 95% Confidence Intervals According to Department Group within the Foundry

	No. of subjects			
	Cases	Controls	RR	95% CI
Total	30(100%)	116(100%)		
Department Group:				
Molding	5 (17)	24 (21)	0.80	0.28,2.32
Core Room	7 (23)	22 (19)	1.40	0.50,3.88
Melting	2 (7)	5 (4)	1.67	0.30,9.39
Finishing	7 (23)	29 (25)	0.93	0.36,2.44
Maintenance	7 (23)	25 (22)	1.14	0.44,2.93

Table 11

Distribution of Cases And Controls, the Matched Rate Ratios with 95% Confidence Intervals According to Department Group within the Engine Plants

	Engine Plant 1			Engine Plant 2			Engine Plants 1 & 2		
	Cases	Controls	RR	Cases	Controls	RR	Cases	Controls	RR
Total	30	116		30	116		30	116	
Machining	12	48	0.98	16	36	2.28*	18	53	1.80
Cast Iron	12	47	1.02	13	25	2.57*	17	51	1.78
Aluminum	3	19	0.61	6	19	1.27	9	29	1.31
Steel	1	3	1.33	2	18	0.40	3	19	0.59
Assembly	11	41	1.06	11	32	1.43	15	53	1.20
Packaging	5	11	1.87	5	8	2.72	6	16	1.55
Maintenance	4	28	0.49	3	14	0.85	6	37	0.55
Stamping	3	8	1.68	-	-	---	3	8	1.68
Administration	3	11	1.10	4	11	1.56	4	14	1.17

* Statistically significant at the 0.05 level.

Table 12
Distribution of Cases and Controls, The Matched Rate Ratio With 95% Confidence Intervals According to Plant

	No. of Subjects			
	Cases	Control	RR	95% CI
Index Plant*:				
Engine Plant 1	23	83	1.37	0.53, 3.56
Engine Plant 2	19	67	1.26	0.56, 2.82
Engine Plants 1 & 2	24	92	1.11	0.40, 3.06
Foundry	17	70	0.87	0.39, 1.93
Index Plant**				
Foundry Only	6	24	1.00	
Engine Plant 1	23	83	1.13	0.40, 3.20
Engine Plant 2	19	67	1.42	0.52, 3.89
Engine Plants+	24	92	1.11	0.40, 3.06
Engine Plants++	12	34	2.89	0.72,11.67

* Ever versus never at index plant.
** Ever engine plant versus foundry only.
+ Ever engine plants 1 or 2
++ Engine plants 1 or 2 only (no foundry employment).

Table 13

Distribution of Cases and Controls, the Matched Rate Ratio with 95% Confidence Intervals According to Type of Cutting Fluids Used in Engine Plant 1

	No. of subjects			
	Cases	Controls	RR	95% CI
Total	30(100%)	116(100%)		
Cutting Fluids[1]				
Water-Soluble	9 (30)	32 (28)	1.15	0.48,2.72
Soluble oils	9 (30)	32 (28)	1.15	0.48,2.72
Synthetic	2 (7)	8 (7)	1.00	0.20,4.90
Semi-Synthetic	3 (10)	12 (10)	0.98	0.25,3.79
Insoluble oils	3 (10)	21 (18)	0.52	0.15,1.86
Dry Machining	3 (10)	11 (9)	1.08	0.27,4.31
Cutting Fluids[2]				
Water-Soluble	9 (30)	32 (28)	1.20	0.38,3.82
Soluble oils	9 (30)	32 (28)	1.20	0.38,3.82
Synthetic	2 (7)	8 (7)	1.09	0.18,6.50
Semi-Synthetic	3 (10)	12 (10)	1.06	0.23,4.99
Insoluble oils	3 (10)	21 (18)	0.61	0.13,2.84
Dry Machining	3 (10)	11 (9)	1.17	0.24,5.81

[1] Ever employed in a department where cutting fluid was used versus never so employed.

[2] Ever employed in a department where cutting fluid was used versus never employed in the engine plants (foundry employment only).

Appendix A

Work History Coding Form

Name:______________________ ___________ ___________
Last First Int. Middle Int.

SSN:________________________

Sex:________________________ 1-Male
2-Female

Race:_______________________ 1-White
2-Black
3-Hispanic
4-Oriental

Date of Birth: ___ ___ ___ ___ ___ ___
Month Day Year

Last Known Vital Status: ___ 1-Deceased
2-Alive
3-Unknown

___ ___ ___ ___ ___ ___
Month Day Year

Dept Code	Job Code	Month	Day	Year
_ _ _ _	_ _ _ _ _ _ _	_ _	_ _	_ _
_ _ _ _	_ _ _ _ _ _ _	_ _	_ _	_ _
_ _ _ _	_ _ _ _ _ _ _	_ _	_ _	_ _
_ _ _ _	_ _ _ _ _ _ _	_ _	_ _	_ _
_ _ _ _	_ _ _ _ _ _ _	_ _	_ _	_ _
_ _ _ _	_ _ _ _ _ _ _	_ _	_ _	_ _
_ _ _ _	_ _ _ _ _ _ _	_ _	_ _	_ _
_ _ _ _	_ _ _ _ _ _ _	_ _	_ _	_ _
_ _ _ _	_ _ _ _ _ _ _	_ _	_ _	_ _

Appendix B

Environment and Health Study at Ford\Brook Park

1. Interviewer: ______________________
   Last Name

2. Interview Date: __ __ Month __ __ Day __ __ Year

3. Time Started: 1. am 2. pm ___ ___ : ___ ___

1. Subject SSN: __ __ __ __ __ __ __ __ __

2. Birthdate: __ __ month __ __ day __ __ year

3. Sex 1. male
   2. female

4. Race: 1. white 4. hispanic
   2. black 5. other ________________ (specify)

5. In what country were you born ______________________

   (if foreign born) How old were you when you entered this country

   (if 0-11 months old, enter as one year) __ __

6. In what country was your mother born________________

7. In what country was your father born________________

8. Excluding kindergarten, how many grades (years) of schooling have you completed

   Grades 1-12 ___ ___

   College 0-4 ___ ___

   Graduate School ___ ___

SMOKING HISTORY

Cigarettes

9. Have you ever smoked cigarettes regularly (at least one a day for a period of one year or longer)

   1. Yes (if yes go to question 11).

   2. No

10. Have you smoked occasionally (at least 100 cigarettes during your entire life)

   1. Yes

   2. No (if no, go to question 17)

11. At what age did you begin smoking ___ ___

12. Do you still smoke

   1. Yes

   2. No

      If stopped, age stopped ___ ___

13. From the time you began smoking, was there a period when you stopped for more than one year

   1. Yes

   2. No

   If yes, how many years from the time you began smoking cigarettes up to the present (time you stopped) had you not been smoking

   ___ ___

14. When you first began smoking regularly how many cigarettes did you smoke per day

   ___ ___

   if current smoker, average number of cigarettes currently smoked per day

   ___ ___

   if stopped, average number of cigarettes you smoked during the two years prior to stopping

   ___ ___

15. Average number of cigarettes smoked per day over entire lifetime ___ ___

16. Total number of years smoked. ___ ___

CIGARS

17. Have you ever smoked cigars?

    1. Yes

    2. No (if no go to question 22)

18. At what age did you first smoke cigars ___ ___

19. Do you still smoke cigars?

    1. Yes

    2. No

    (if no) At what age did you stop ___ ___

20. Usual number of cigars smoked per day ___ ___

21. Total number of years you smoked cigars ___ ___

PIPES

22. Have you ever smoked a pipe?

    1. Yes

    2. No (if no go to next section)

23. At what age did you begin smoking a pipe? ___ ___

24. Do you still smoke a pipe?

    1. Yes

    2. No

    (if no) At what age did you stop ___ ___

25. Usual number of pipe bowls smoked per day ___ ___

26. Total number of years you smoked a pipe ___ ___

OCCUPATIONAL HISTORY

I would like to ask you about the jobs that you (worker name) had before and after your employment at Brook Park (including jobs that you held at other Ford facilities). Start with the most recent job and work backwards. Include jobs sustained during military service, farming, and self-employment.

1. What is the name and location of the company you worked for on the last job you held for six months or longer?
2. What type of place is this; that is, what did you make or do?
3. What was your job title at (COMPANY NAME)?
4. Was this a full or part-time job?
5. What year did you start working as a (JOB TITLE)?
6. What year did you stop working as a (JOB TITLE)?
7. What were your duties when you worked as a (JOB TITLE)?

OCCUPATIONAL HISTORY

1. Company Name: ______________________________

Company Location: ______________________________
(City) (State)

Type of Company: ______________________________

Job Title: ______________________________

Full Time: ______________ Part Time: ______________

Year Started: ______________ Year Ended: ______________

Duties ______________________________

____

____

____

____

____

OCCUPATIONAL HISTORY

2. Company Name: ______________________________

   Company Location: ______________________________
   (City) (State)

   Type of Company: ______________________________

   Job Title: ______________________________

   Full Time: ______________ Part Time: ______________

   Year Started: ______________ Year Ended: ______________

Duties ______________________________

____

____

____

____

____

OCCUPATIONAL HISTORY

3. Company Name: ____

Company Location: ____
(City) (State)

Type of Company: ____

Job Title: ____

Full Time: ____________________ Part Time: ____________________

Year Started: ____________________ Year Ended: ____________________

Duties ____

____

____

____

____

____

To be sure that I have not missed any important jobs please tell me if you worked for 6 months or longer in any of the following industries or ever handled any of the following materials:

INDUSTRIES: DATES

1. Smelting Y/N/U From To

Type ______________________ _______ _______

Job Title ______________________

Exp Arsenic/Nickel/Chromium

2. Metal Cutting/ Grinding Y/N/U From To

Type ______________________ _______ _______

Job Title ______________________

Exp Abrasive/metal Dust/Coolants/Lubricants

3. Metal Plating/Operations Y/N/U From To

Type ______________________ _______ _______

Job Title ______________________

Exp Chromium/Nickel

4. Rubber/Tire Y/N/U From To

Type ______________________ _______ _______

Job Title ______________________

Exp Stabilizers/Curing Fumes/Synthetic Rubber Production/Benzene

5. Leather Y/N/U From To

Type ______________________ _______ _______

Job Title ______________________

Exp Leather Dust/Arsenic/Formaldehyde

6. <u>Refineries</u> Y/N/U From To

Type ____________________ ______ ______

Job Title ____________________

Exp Acid Mists/Nickel/Arsenic/Chromium/Petro Chemicals/Lubricants/Petroleum Tars-Pitch

7. <u>Mining</u> Y/N/U From To

Type ____________________ ______ ______

Job Title ____________________

Exp Chromium/Uranium/Asbestos/Iron/ Coal Dust/Radiation

8. <u>Battery Operations</u> Y/N/U From To

Type ____________________ ______ ______

Job Title ____________________

Exp Lead/Cadmium/Acids/Nickel

9. <u>Plastics</u> Y/N/U From To

Type ____________________ ______ ______

Job Title ____________________

Exp Formaldehyde/Vinyl Chloride

10 <u>Coke Ovens</u> Y/N/U From To

Type ____________________ ______ ______

Job Title ____________________

Exp Coke oven emissions

11 <u>Foundry Work</u> Y/N/U From To

Type ____________________ ______ ______

Job Title ____________________

Exp Foundry Dust/Soot/Formaldehyde

12 <u>Insulating</u> Y/N/U From To

Type ____________________ ______ ______

Job Title ____________________

Exp Asbestos/Urea Formaldehyde Foam

13 <u>Printing</u> Y/N/U From To

Type ____________________ ______ ______

Job Title ____________________

Exp Chromium/Cobalt

14 <u>Painting</u> Y/N/U From To

Type ____________________ ______ ______

Job Title ____________________

Exp Object Painting/House-Cars-Boats-Appliances

15 <u>Ship Building</u> Y/N/U From To

Type ____________________ ______ ______

Job Title ____________________

Exp Asbestos/Radiation/Welding Fumes/Coolants/ Lubricants

16 <u>Textiles</u> Y/N/U From To

Type ____________________ ______ ______

Job Title ____________________

Exp Formaldehyde

17 <u>Wood Products Manufacturing</u>

Y/N/U From To

Type ____________________ ______ ______

Job Title ____________________

Exp Wood Dust/Formaldehyde/Paint-Varnish Strippers

18 Rock Mining/Quarry

	Y/N/U	From	To
Type	____________________	______	______
Job Title	____________________		
Exp	Rock Dust/Radioactive Material/Asbestos		

19 Cement

	Y/N/U	From	To
Type	____________________	______	______
Job Title	____________________		
Exp	Cement Dust		

20 Glass Ceramic

	Y/N/U	From	To
Type	____________________	______	______
Job Title	____________________		
Exp	Nickel/Formaldehyde/Glass Fiber/Wool		

21 Pipe Fitting/Plumbing

	Y/N/U	From	To
Type	____________________	______	______
Job Title	____________________		
Exp	Asbestos/Cement Dust/Welding Fumes/Soldering		

Medical History

Has a doctor ever told you (workers name) that you have cancer?

1. Yes
2. No

If yes, type of cancer:______________________________

Date of Diagnosis: ___ ___ month ___ ___ day ___ ___ year

Name of Diagnosing Physician:______________________________

Address of Diagnosing Physician:______________________________
City

____
State Zip

Telephone:(   ) ___ ___ ___   ___ ___ ___ ___

At what hospital were you diagnosed:______________________________

____
City State

Name of Physician who treated you (workers name):__________

Address of treating physician:______________________________
City

____
State Zip

Telephone (   ) ___ ___ ___   ___ ___ ___ ___

At what hospital were you (workers name) treated:__________

____
City State

Name of person interviewed

____
Last First MI

Address ______________________________

____
City State Zip

Phone (   ) ___ ___ ___   ___ ___ ___ ___

<u>Relationship to Subject:</u>

1. Wife/Husband
2. Son
3. Daughter
4. Brother/Sister
5. Other ______________________
   Specify
6. Subject

Time Ended: 1. am 2. pm __ __ : __ __

GRADUATE SCHOOL
UNIVERSITY OF ALABAMA AT BIRMINGHAM
DISSERTATION APPROVAL FORM

Name of Candidate Charles Rotimi

Major Subject Epidemiology

Title of Dissertation "A Follow-up Study of Mortality and a Nested Case-control Study of Stomach Cancer among Foundry and Automobile Engine Manufacturing Plant Workers"

Dissertation Committee:

Philip Cole, Chairman   Elizabeth Delzell

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Date 30 Oct '91

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