Mesothelioma Incidence

And

Community Asbestos Exposure

Environmental Health Services

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by

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ABSTRACT

The purpose of this study was to evaluate the incidence of mesothelioma among persons living in an area that had been the location of an asbestos manufacturing plant between 1912 and 1980. Two study designs were used: standardized incidence ratios and a case-control format. Only vital record data were used in this project.

Cases were the 110 diagnosed mesotheliomas among residents in Somerset County reported to the population-based New Jersey State Cancer Registry from 1979 through 1987. Cases were removed from the analysis when their "usual employment" was reported as being at the asbestos plant, as evidenced through union lists or occupational information from either the Cancer Registry or mortality records.

Standardized Incidence Ratios (SIR) were computed for total Manville residents, and for males and females separately. Average annual New Jersey mesothelioma rates, 1979-1986, were used to generate the expected number of mesothelioma cases. The SIR for the total Manville population was 14.9 (95% Confidence Interval [C.I.]: 9.1-23.1). Female Manville residents had a mesothelioma SIR of 29.7 (95% C.I.: 11.9-61.3). Male Manville residents had a mesothelioma SIR of 11.4 (95% C.I.: 6.1-19.5). Total and male Somerset County mesothelioma incidence were slightly elevated compared to the State rates.

Controls for the case-control study design included the 1,016 selected cancers deemed unrelated to asbestos exposure. The controls were also residents of Somerset County at time of diagnosis and diagnosed during the same time period as the cases. Using logistic regression analysis, explanatory variables included town of residence, age at diagnoses, and year of diagnoses stratified by sex. For males, residence in Manville had an odds ratio of 6.4 (95% C.I.: 3.0-13.5) compared with residence in other county locations. For females, the odds ratio for residence in Manville was 31.7 (95% C.I.: 8.7-116.1).

These record-based approaches demonstrate a strong relationship between past asbestos exposure from living in Manville and eventual development of mesothelioma. The use of such study designs may be helpful in evaluating hazards of known occupational carcinogens found in community settings.

INTRODUCTION

Mesothelioma is a rare type of cancer. The National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) Program estimates that mesothelioma occurs nationally at an annual rate of 14 cases per million population for males and 3 cases per million population for females (NCI, 1987).

Mesothelioma incidence in New Jersey (calculated for this study using average annual unadjusted rates from 1979 through 1986) is higher than SEER estimates: 19 male cases per million population and 4.4 female cases per million population. However, mesothelioma incidence is not uniformly distributed throughout New Jersey's 21 counties; the mesothelioma rates in Somerset County are approximately 5 times higher (105 per million males and 21 per million females) than the average state rate and about 7 times the national rate.

New Jersey has traditionally been the center of operations for many asbestos products manufacturers and shipyards (Stanbury and Rosenman, 1987). Between 1912 and 1980, Manville, located in Somerset County, was the site of the largest asbestos products manufacturing plant in North America. The plant employed up to 3,500 people at one time and manufactured asbestos products for over seventy years.

In 1987, NJDOH conducted a death certificate analysis of mesothelioma and residence in Somerset County (Miller et al., 1988). That study was designed to evaluate the cancer risk removing the effect of employment at the asbestos plant through the

use of a union employment list. Miller et al. (1988) detected a significantly elevated odds ratio of 4.4 ($p<0.02$) for living in Manville. The small number of cases and possible coding errors on death certificates of mesothelioma to other cancer types in this earlier study suggested follow-up of these observations. The purpose of the present study was to evaluate the environmental (non-occupational) component of this rare cancer among persons living in an area that had an asbestos manufacturing plant with potentially significant population exposures (Borow and Livornese, 1973).

METHODS

Study Area and Period

The study area for the mesothelioma investigation included the total area and population of Somerset County, New Jersey. Manville, in Somerset County, was considered the focal point of highest environmental exposure to ambient asbestos fibers due to the operation of a large asbestos manufacturing plant. For purposes of this study, the population living in Manville at the time of cancer diagnosis was designated the "exposed" population. The comparatively "unexposed" population was defined as those persons living in Somerset County but not in Manville at the time of cancer diagnosis.

The time period of interest in this study was 1979 through 1987, a nine-year study period. This study period was chosen because 1) a sufficient period of time (at least 60 years) had elapsed from earliest possible ambient exposures from the plant to

the expression of mesothelioma in the community (to account for the latency of the disease) and 2) the New Jersey State Cancer Registry had complete records for the study time period.

For the purpose of calculating statistics for this investigation, the 1980 U.S. Census Bureau population data were selected for Somerset County municipalities. The 1980 Census figures were compiled within the study period and provide the most representative estimate of the size and age structure of the study population.

Case and Control Ascertainment

The New Jersey State Cancer Registry was used for the ascertainment of both cases and controls. The Cancer Registry, operated by the New Jersey Department of Health, is a population-based cancer incidence registry covering the entire state of New Jersey. By law, specific data on all individuals residing within New Jersey who have newly diagnosed cancers must be reported to the Registry. In addition, the Registry has reporting agreements with neighboring states (Delaware, New York, and Pennsylvania), where information on New Jersey residents that are diagnosed in those states will be supplied to the New Jersey Cancer Registry.

A case was defined as a new primary incident mesothelioma cancer (ICD-O histology code: 9050-9053) that occurred in a Somerset County resident between January 1, 1979, through December 31, 1987. The histology code is defined by the tissue type of the neoplasm and includes both pleural and peritoneal mesotheliomas.

A control series was selected from the Cancer Registry data

base to include specific cancer types diagnosed in Somerset County residents during the study period. Control cancer types were chosen based on an earlier NJDOH mortality study of mesothelioma (Miller et al., 1988). The cancer types selected for males included: liver, prostate, thyroid, and Hodgkins disease. The cancer types selected for females included: cervical, myeloma, Hodgkins disease, and non-Hodgkins lymphoma. These control cancers were believed to be unrelated to either an asbestos etiology or residential location within the county.

Information for each newly diagnosed cancer available from the Cancer Registry was limited to the Cancer Registry abstract of information from the patient medical record. The collected information included demographic data on each patient and medical data on each cancer. Variables used to analyze the incidence of cancer in the county included: name, address at time of diagnosis, county and municipality codes, occupation and industry codes, date of diagnosis, primary cancer site, histology type, age at diagnosis, date of birth, race, sex, and Registry identification number.

Information on other risk factors such as the extent of occupational exposure or personal life style habits were unknown for the study population. No personal interviews or other means of data collection for these factors were feasible for this project. We recognize, however, potential risk factors that cannot be accounted for in the study design may vary significantly within the study area or relative to the State as a whole.

Removal of Occupational Cases

To better evaluate the impact of environmental exposure to asbestos, mesothelioma cases that were identified through one of three sources as having worked at the asbestos plant in Manville were removed prior to analysis. The three data sources used to determine the occupation of the cases were: Cancer Registry records, death certificates, and a list of all members of the single Union representing employees at the plant. The Cancer Registry and death certificates provided information on the usual occupation, type of business or industry, and the name and address of employer. The Union list was comprised of all unionized employees at the asbestos plant who started working between October 1912 and December 1958. The control series was not evaluated for occupation since asbestos exposure was not a risk factor for the control cancers used in this study.

Data Analysis

Standardized Incidence Ratios: The first analysis focused only on the mesothelioma cases in relation to average State mesothelioma rates. Standardized Incidence Ratios (SIRs) were calculated for mesothelioma for both Manville and for all of Somerset County exclusive of Manville. The SIR was calculated by dividing the observed number of cases by the expected number of cases. The expected number was mathematically derived by multiplying the State average annual age-sex-specific mesothelioma incidence rates, 1979-1986, with the study area age-sex specific population figures for 1980. The 95% confidence intervals of the

SIRs were calculated to assess statistical significance using the estimation method of Byer (Breslow and Day, 1985).

Logistic Regression: In order to conduct an internal comparison within Somerset County, cases of mesothelioma were contrasted with certain other cancer cases (controls) with regard to residence in Manville. The number of mesothelioma cases among Manville residents ("exposed") versus the rest of Somerset County ("unexposed") was fitted to a logistic regression model, which is a statistical model of an individual's risk or probability of disease as a function of some set of n independent factors. The model produces odds ratios (ORs) which compare the relative odds of exposure between the cases and controls. Age, residential location at time of diagnoses, and year of diagnoses were included in the model and stratified on gender. The general method as described by Breslow and Day (1981) and Prentice and Pyke (1979) was performed using the statistical software package EGRET for the analysis.

RESULTS

Study Population

The 1980 population of Somerset County was 203,129 (males = 99,671 or 49.07%). Manville's population represented 5.6 percent of the county and was 11,278 in 1980 (males = 5,489 or 48.67%). The median age for Manville and Somerset County residents was similar for both males and females (31 and 33 years of age, respectively). The percent of the population aged 65 and over varied slightly between Manville and Somerset County (males, 7.8% and 7.3%, and females, 9.5% and 10.6%, respectively). Manville had

a greater percentage of white residents compared to Somerset County (99% and 93%, respectively).

A total of 110 mesothelioma cases (93 males and 17 females) were identified in Somerset County over the nine year study period, 1979 through 1987 using the New Jersey State Cancer Registry records. The control series identified through the Registry yielded 1,016 non-mesothelioma cancer cases (566 males and 450 females) for the entire county.

Removal of Asbestos Plant Employee Mesothelioma Cases

Of the 110 mesothelioma incident cases in Somerset County, a total of 46 cases were identified as persons having worked at the Manville plant (Table 1). The breakdown for method of identification was 41 by death certificates (41/46 or 89.1%), 33 by the union list (33/46 or 71.7%), and 27 by the Cancer Registry (27/46 or 58.7%). (Note: the methods were not mutually exclusive.) Death certificates were located for 104 (94.5%) of the mesothelioma cases.

Of the 46 identified as having had previous employment at the plant, 24 were residents of Manville at time of diagnosis and the other 22 resided elsewhere in the county.

A total of 64 cases (49 males and 15 females) had no evidence of employment at the plant in any of the available data sources. These 64 cases were used for all the following analyses.

Data Analysis

Standardized Incidence Ratios (SIR): Table 2 presents the results of the SIR analysis. Mesothelioma incidence in Manville

residents who did not work at the plant was significantly elevated for males, females, and the total population relative to average State rates. Manville females had the highest SIR for mesothelioma, 29.7 (95% Confidence Interval [C.I.]: 11.9-61.3). The SIR for the total Manville population was 14.9 (95% C.I.: 9.1-23.1). The SIR for males was 11.4 (95% C.I.: 6.1-19.5).

The SIR analysis for the rest of Somerset County detected significantly elevated rates for males and the total population. However, the difference between the observed and expected numbers was much smaller than for the Manville SIRs: total Somerset County population SIR = 2.1 (95% C.I.: 1.5-2.8).

Logistic Regression: Table 3 presents the age, race, and sex frequencies of cases and controls. Since there was such a high percentage of whites in the study population, race was not included as a variable in the analysis. The mean age differential for female cases and controls (68 verses 49) is likely due to the younger average age of diagnosis of the selected control cancers compared to the older age of diagnosis for mesothelioma. Manville mesothelioma cases tended to be diagnosed at a younger age on average than mesothelioma cases in the rest of the county (60 verses 66).

Table 4 presents the results of the logistic regression analysis. After removing the effect of working at the plant, living in Manville had a statistically significant association with mesothelioma incidence. The odds ratio for males living in Manville was 6.4 (95% C.I.: 3.0-13.5). Years of age at diagnoses

were significantly but inversely associated with mesothelioma incidence (OR=0.96; 95% C.I.: 0.95-0.97). For females, the odds ratio for living in Manville was 31.7 (95% C.I.: 8.7-116.1) and for increasing years of age at diagnoses the odds ratio was 1.07 (95% C.I.: 1.03-1.11). Year of diagnosis was not associated with mesothelioma for either sex and, therefore, was not included in the final model.

DISCUSSION

The purpose of this study was to evaluate the environmental, non-occupational component of mesothelioma in an area that had a long-term asbestos manufacturing operation. These data indicate that residents of Manville had an extremely elevated risk of developing mesothelioma relative to average state incidence rates and also when compared with other municipalities in the same county. A union employee list and vital statistic data were used to minimize the effect of the occupational component of this disease, leaving a more accurate assessment of the environmental impact to the community. However, since full occupational histories were not collected for the mesothelioma cases, it is possible that some of the cases may have worked at the Manville facility sometime during their life. The impact of this type of misclassification of employment would be to overestimate the environmental component in the analysis.

Asbestos exposure had been suspected as a risk factor for mesothelioma since 1943 (NCI, 1987), but not until 1960 did a study of asbestos miners and neighborhood residents in South Africa

(Wagner et al., 1960) firmly establish an association. Numerous occupational studies have documented increased risks among workers in asbestos mines and factories, installation, shipbuilding, and other occupations involving inhalation of asbestos dust (IARC, 1977; McDonald and McDonald, 1978; Newhouse, 1977; Selikoff, 1977; Selikoff and Hammond, 1979; Tagnon et al., 1980).

The South African report (Wagner et al., 1960) noted that one-third of the mesothelioma cases had no employment history associated with asbestos. These non-occupational cases were exposed to asbestos because of their living near asbestos mines and mills. Two European studies (Newhouse and Thompson, 1965; Hain et al., 1974) detected excess cases in the immediate neighborhood of factories which processed asbestos, mainly from the same South African mines (McDonald, 1985). Household contacts of asbestos workers were also at elevated risk for asbestos-induced diseases including mesothelioma (Newhouse and Thompson, 1965; McDonald and McDonald, 1980; Anderson et al., 1979; Vianna and Polan, 1978).

Although the larger, heavier asbestos particles settle to earth relatively quickly with limited potential for environmental (off-site) contamination, an appreciable fraction of the asbestos discharged by asbestos facilities has been documented to be in the form of free fibers that could potentially remain in the atmosphere for long periods of time, travel great distances, and expose many people (Laamanen et al., 1964). Laamanen's studies of atmospheric pollution in the area surrounding asbestos mines and mills in Finland showed small amounts of asbestos dust as far away as 27

kilometers.

The two major routes of environmental exposure for the current study were considered to be ambient air and household contact with plant employees. Based on anecdotal information from residents and plant employees, the asbestos manufacturing operation in Manville produced large quantities of particles that were released into the ambient air. Asbestos contamination of the community over the decades of operation could persist due to the stability of the fibers. Hammond et al. (1979) reported that dust samples collected from houses located near an asbestos factory contained appreciable amounts of asbestos fiber even many years after the factory closed.

The asbestos plant in Manville was a multi-end product manufacturing facility that primarily used chrysotile asbestos (approximately 95%). A gradual reduction of asbestos use began in the early 1970's with an abrupt shift to substitute materials or elimination of product line in 1980. There is some information suggesting that chrysotile fibers are not as hazardous as other types of asbestos, especially crocidolite (NCI, 1981). An important distinction between this study and other affected neighborhood studies (Wagner et al., 1960; Newhouse and Thompson, 1965; Hain et al., 1974; McDonald, 1985) is the type of asbestos fibers contaminating the environment. Although crocidolite was the major form of asbestos in the earlier studies, this study suggests a major community impact by a facility using primarily chrysotile fibers.

Mesothelioma incidence rates in Somerset County were found to

be substantially elevated, approximately six-fold, during the 1980's relative to state and national rates. Incidence in Somerset County exclusive of Manville remained statistically elevated and twice the average state rates. Manville mesothelioma rates compared to average state rates were found to be extremely elevated and highly associated with residence relative to the rest of the county. Possible explanations for the elevated county mesothelioma incidence could include a carry-home effect due to plant employees living outside of Manville and out-migration of Manville residents to other locations within the county prior to their diagnosis.

A limitation of this study was the inability to distinguish between cases attributable to ambient airborne contamination or household contact with an asbestos worker. However, it has been estimated that neighborhood asbestos exposure and family contact are roughly equal in their community impact (Newhouse and Thompson, 1965).

Most of the potential sources of bias in the study design tend to underestimate the measure of effect (bias toward the null hypothesis of no effect). Since mesothelioma cases among the asbestos workers were excluded, all asbestos workers living in the county should be theoretically removed from the population estimates (Census data) for Manville and Somerset County, but this was not feasible. This is especially important for Manville since the facility was the major employer in the town and likely employed many of the residents in Manville. Additionally, the State mesothelioma rates are certainly inflated by the rates in Somerset

County, resulting in bias towards the null for the SIRs. Finally, recent in-migration of unexposed people and/or out-migration of mesothelioma cases prior to diagnosis would also bias the SIRs for Manville towards the null.

Another potential problem is the possible miscoding or absence of occupational information in the vital statistics records used in this study. Although 46 of 110 Somerset County mesothelioma cases were identified as having worked at the Manville plant, the lack of definitive evidence of employment obtained through occupational histories for the other 64 cases could lead to false negatives. Since there were no interviews conducted to verify occupational history, some of the cases included in the analysis may have worked at the Manville plant. Similarly, Somerset County mesothelioma cases could have had a history of previous residence in Manville.

This study used incidence data from a population-based Cancer Registry for case ascertainment instead of death certificates because of the greater sensitivity of detecting mesothelioma cases (Ducic, 1971; McDonald, 1979; Newhouse and Wagner, 1969). However, death certificates identified more of the mesothelioma cases as having a previous employment at the plant for this study compared to the union list or the Cancer Registry (89% verses 59% and 72%, respectively).

The excess risk yielded in these analyses in the vicinity of the asbestos plant is consistent with that which would be anticipated based on previous qualitative accounts of asbestos fibers emitted into ambient air and/or carried home on worker's

clothing or other articles (Wagner et al., 1960; Newhouse and Thompson, 1965; Hain et al., 1974; McDonald and McDonald, 1980).

The relationship between asbestos and mesothelioma is unusual in the epidemiology of diseases caused by environmental factors in that, other than asbestos, there are no other known or suspected causes for this rare cancer (NCI, 1987). Asbestos exposure appears to be necessary for the development of mesothelioma, i.e., there is specificity of exposure for this effect. Such specificity is not found for most other environmental exposures demonstrated to cause diseases. Nevertheless, this study does have implications for other environmental toxics which may not be the only cause of the diseases for which they are associated. Asbestos is the prime example of a substance for which the detrimental effects have been demonstrated almost exclusively in the occupational arena. Many exposures shown to be toxic in the occupational setting are presumed to pose similar kinds of hazards at lower levels in the environment. While such presumptions are good public health practice, demonstration of consistency of effect and dose-response is extremely useful for indicating that preventive actions in the community are well grounded. As another example, this agency has used a case control design for residential radon exposure (Schoenberg et al. 1990) with results supporting the extrapolation of unit radon risks from mines to homes, thereby underscoring the plausibility of the national and state citizen advisories already in effect. In a similar manner, this mesothelioma study can serve to strengthen the public health underpinning of activities already

in place which serve to prevent community exposure to asbestos.

CURRENT SITE STATUS

The Manville plant ceased manufacturing asbestos products in 1980 and closed altogether in 1986. A state-mandated cleanup of the site, which began in 1989 under the Environmental Cleanup Responsibility Act (ECRA), was completed in December 1992. The ECRA cleanup included remediation of most of the buildings on-site and capping of a large asbestos dump with soil and stone. The property was sold and a controlled demolition of the buildings has recently been completed. On-site air monitoring during the demolition did not detect any ambient air contamination.

For years employees of the plant sought financial compensation from the company for their asbestos-related diseases. Because of the huge potential liability of lawsuits from former employees, the company filed for bankruptcy in 1982. Under bankruptcy law, a corporation is allowed to satisfy its creditors and continue operations as a reorganized business. As part of the terms of the bankruptcy reorganization, a trust fund was established to compensate persons with asbestos-related illnesses. Community health concerns are primarily addressed through individual physicians.

PUBLIC HEALTH ISSUES

1. Residents in such communities who are experiencing respiratory problems should seek medical evaluation and counseling from their physician.

2. Family members who lived with former asbestos workers should

inform their physician that they may have been exposed to high levels of asbestos.

3. Local Health Departments, medical facilities, and physicians in areas that once had significant asbestos manufacturing or shipbuilding should be notified that an elevated risk of asbestos disease could be present in their communities due in part to environmental exposure to asbestos. Health education and outreach programs should be developed for affected communities.

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TABLE 1. NEW JERSEY, SOMERSET COUNTY NEWLY DIAGNOSED MESOTHELIOMA CASES AND EMPLOYMENT HISTORY AT THE MANVILLE ASBESTOS PLANT. STUDY PERIOD: 1979 - 1987.

Identified Employment at JM Corp	Source of Employment Data *	Mesothelioma Cases Male **	Female	Total Cases
Yes:	DC,UL, and CR	18		18
	DC and UL	11		11
	DC and CR	7	1	8
	DC only	3	1	4
	UL only	4 (1)		4
	CR only	1 (1)		1
	Total Yes	44 (2)	2	46
No Evidence:		49 (4)	15	64
Total:		93 (6)	17	110

* Source of Employment Data: DC = Death Certificate
UL = Union List
CR = Cancer Registry

** Parenthetical numbers are cases without Death Certificates.

TABLE 2. NEW JERSEY, SOMERSET COUNTY MESOTHELIOMA STUDY: 1979 - 1987. COMPARISON OF THE OBSERVED AND EXPECTED MESOTHELIOMA CASES FOR MANVILLE AND SOMERSET COUNTY.

Population	Observed	Expected	SIR	95% C.I. Lower - Upper
Manville:				
Total	20	1.34	14.94 *	9.12 - 23.07
Male	13	1.14	11.41 *	6.07 - 19.51
Female	7	0.24	29.74 *	11.91 - 61.28
Somerset County except Manville:				
Total	44	20.86	2.11 *	1.53 - 2.83
Male	36	17.48	2.06 *	1.44 - 2.85
Female	8	3.83	2.09	0.90 - 4.12

* Statistically elevated, $p < 0.05$

TABLE 3. NEW JERSEY, SOMERSET COUNTY MESOTHELIOMA STUDY: 1979 - 1987. AGE, RACE, AND SEX COMPARISON OF CASES AND CONTROLS

Demographic Feature	Mesothelioma Cases	Selected Cancer Controls
MALES		
Number:	49	566
Average Age:	63.2	67.8
Standard Deviation:	10.3	14.1
Percent White:	98.0%	93.1%
FEMALES		
Number:	15	450
Average Age:	68.2	48.7
Standard Deviation:	10.4	19.9
Percent White:	100%	85.6%

TABLE 4. NEW JERSEY, SOMERSET COUNTY MESOTHELIOMA STUDY: 1979 - 1987. LOGISTIC REGRESSION ANALYSIS

Term	Coefficient	Standard Error	Odds Ratio	95% Confidence Interval Lower - Upper	P-Value
MALES					
Residence in Manville at diagnoses:	1.91	0.38	6.38	3.01 - 13.52	< 0.001
Age at diagnoses:	-0.04	0.01	0.96	0.95 - 0.97	< 0.001
FEMALES					
Residence in Manville at diagnoses:	3.46	0.66	31.72	8.67 - 116.1	< 0.001
Age at diagnoses:	0.07	0.02	1.07	1.03 - 1.11	< 0.001