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Cancer Mortality Among Northern Georgia Carpet and Textile Workers

Thomas R. O'Brien, MD, MPH, and Pierre Decouflé, ScD

Proportionate cancer mortality was analyzed among white male carpet and textile workers in five northwest Georgia counties for the years 1970-1984. Compared with other Georgians, carpet and textile workers had higher proportions of lymphocytic leukemia (proportionate cancer mortality ratio [PCMR] = 2.9; 95% CI = 1.4-5.4) and testicular cancer (PCMR = 3.2; 95% CI = 1.0-7.5). The excess mortality from lymphocytic leukemia was even higher when the analysis was limited to workers deemed most likely to work directly in production areas (PCMR = 4.2, 95% CI = 1.7-8.7). Further studies are needed to determine if the observed excesses are the result of workplace exposures.

Key words: textile, carpet, cancer, leukemia, testicular cancer, proportionate mortality

INTRODUCTION

Although occupational cancer is an important and potentially preventable cause of mortality, the United States has no national occupational cancer mortality surveillance system. Death certificates are used in occupational mortality surveillance by other nations and in several states, including Washington State, where Milham [1983] monitored occupational mortality with proportionate mortality studies. Dubrow et al. [1987] recently described joint efforts of the National Institute for Occupational Safety and Health, the National Center for Health Statistics, and 31 collaborating states to expand the use of death certificates in occupational mortality surveillance. They also summarized the limitations of this approach.

Occupational surveillance on a state-by-state basis is valuable because industries are often regionalized. Carpet manufacturing is one such industry—over 50% of this country's carpet manufacturing plants are located in Georgia [US Bureau of the Census, 1982a]. To explore the possibility that carpet production work is associated with increased cancer risks, we have examined proportionate cancer mortality in a group of carpet and textile workers in northern Georgia.

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Fig. 1. Five-county study area in Northwest Georgia.

BACKGROUND

Carpet manufacture began in Georgia in the 1930s and expanded rapidly after the development of synthetic carpet fibers in the late 1950s [Hoover Home Institute, 1983]. The carpet industry is now the dominant employer in a number of Georgia counties and is the state's third leading industry. About 284 plants employ about 24,000 Georgians in carpet manufacture [US Bureau of the Census, 1982b]. Georgia primarily produces tufted carpets, with processes that grew out of bedspread manufacture. Typically, the process involves inserting tufts of synthetic yarn into a primary backing with a machine that resembles a large sewing machine. The carpet is then dyed and finished with a secondary backing of latex and other materials which holds the yarn in place [Hoover Home Institute, 1983].

The Georgia carpet industry is neither unionized nor dominated by a few large employers, so no easily defined cohort of workers was available for retrospective analysis. However, cause of death and occupational and industry statements were available on Georgia death certificates. As we were primarily interested in occupationally related cancers, we undertook a proportionate cancer mortality study.

MATERIALS AND METHODS

A computer tape of Georgia's 1970-1984 mortality records was provided by the Georgia Department of Human Resources. To increase the likelihood that decedents with vaguely worded industry statements (i.e., textile) were carpet workers, we studied the five Georgia counties (Catoosa, Gilmer, Gordon, Murray, and Whitfield) that have the highest percentage of carpet industry employment [US Bureau of the Census, 1984]. These counties are located in northwest Georgia (Fig. 1) and have a combined population of about 165,000 [Hodler and Schretter, 1986]. About 45% of the employed population in these counties works in the textile industry (including carpet), and almost 80% of these textile workers are employed in carpet manufacture

TABLE I. Distribution of Occupations, 20-74 Years, 1970-1984

Carpet/textile
Production work lik.
Production work po
Production work at
No occupation given
Total
Other industry
Industry unclassifiable
Total study area

[US Bureau of the Census, 1984]. The study area was defined as the five-county area because, prior to 1970, the data from the computerized files of the 1,356 retrievable decedents' cause of death were classified into three categories: carpet/textile, or textile as the decedent's occupation, or area were carpet/textile as carpet/textile as the decedent's occupation. The retrievable decedents' cause of death was determined from the death certificate. Carpet/textile workers were production workers, classified as to likelihood of the occupational statement that they were in the industry. Thus, the study area was defined as the five-county area.

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TABLE I. Distribution of Study Area Decedents by Industry/Occupation, White Males Aged 20-74 Years, 1970-1984

	No.	Percent
Carpet/textile		
Production work likely	161	41.7
Production work possible	79	20.8
Production work unlikely	55	14.2
No occupation given	91	23.6
Total	386	28.5
Other industry	930	68.6
Industry unclassifiable	40	2.9
Total study area	1,356	100.0

[US Bureau of the Census, 1984]. We further restricted the study to white males who were aged 20-74 years at death. Deaths at ages 75 and older were excluded because of the greater likelihood of inaccurate occupational information for the elderly.

Altogether, 1,403 death certificates met these age, race, sex, year of death, and geographic restrictions. However, 47 death certificates could not be retrieved because, prior to 1976, the names of Georgians who died out of state were excluded from the computer record. We abstracted occupational and industry statements from the 1,356 retrievable certificates and then coded them, without knowing the decedent's cause of death (see Appendix). Death certificates were first classified into three categories according to industry: 1) carpet/textile, 2) industry other than carpet/textile, or 3) no identifiable industry. Many death certificates simply listed textile as the decedent's usual industry. Since most textile workers in this five-county area were carpet workers, we included all workers with an industry statement of textile as carpet/textile workers. So defined, carpet/textile workers formed 28.5% of the retrievable death certificates (Table I). Decedents for whom industry could not be determined formed only 2.9% of the total; they were excluded from all analyses. Carpet/textile workers were then classified as likely, possibly, or unlikely to have been production workers. Ninety-one carpet/textile workers (23.6%) could not be classified as to likelihood of production work because of insufficient information in the occupational statement. The 55 subjects whose occupational statement suggested that they were unlikely to have been involved in production were excluded from analyses. Thus, the final study group of carpet/textile workers comprised 311 men.

Deaths from all forms of cancer combined and for 32 specific cancer sites were tabulated for three groups: among carpet/textile workers, other residents of the five-county area, and for a comparison population composed of all Georgia residents who met the previously described age, race, sex, and year-of-death criteria. Decedents from the five-county study area were not excluded from the comparison group, but, since they made up only 3.8% of the total group, their inclusion did not materially alter the results. Table II shows the year-of-death and age-at-death distributions for all cancer deaths among carpet and textile workers, other residents of the study area, and the comparison population. To determine whether observed differences in cancer mortality resulted from using a comparison group that included many urban residents, we also employed a second comparison group that excluded decedents from the five-county metropolitan Atlanta area.

A proportionate cancer mortality ratio (PCMR) [Monson, 1980], adjusted for

TABLE II. Distribution of North Georgia Carpet and Textile Workers, Other Study Area Residents, and the Comparison Population by Year of Death and Age at Death

Age at death (years)	Calendar year of death			
	1970-1978		1979-1984	
Carpet and textile workers (N = 331) ^a				
20-49	25	(7.6)	16	(4.8)
50-64	81	(24.5)	86	(26.0)
65-74	44	(13.3)	79	(23.9)
Other study area residents (N = 930)				
20-49	63	(6.8)	49	(5.3)
50-64	223	(24.0)	186	(20.0)
65-74	195	(21.0)	214	(23.0)
Comparison population (entire state) (N = 38,062)				
20-49	2,770	(7.3)	1,898	(5.0)
50-64	9,682	(25.4)	7,629	(20.0)
65-74	8,271	(21.7)	7,812	(20.5)

^aFigures in parentheses represent the number of deaths in a specified age and calendar year subgroup as a percent of the total number of deaths in each of the three population groups.

age at death (strata = 20-29, 30-39, 40-49, 50-54, 55-59, 60-64, 65-69, and 70-74 years) and calendar year (strata = 1970-1978 and 1979-1984), was determined for each site by a specially written computer program. Year of death was categorized to coincide with changes in the International Classification of Diseases. Ninety-five percent confidence intervals were calculated for each PCMR by approximating the exact binomial interval. When five or more deaths were expected for a cancer site, the approximation was based on the normal distribution [Fleiss, 1981]. When less than five deaths were expected, the Poisson distribution was used. Cancer sites with no deaths among carpet/textile workers are not shown, and the PCMR and 95% confidence intervals are not shown for sites where both observed and expected deaths are less than five.

RESULTS

Greater than twofold excesses of genital (nonprostatic) cancer and lymphocytic leukemia were observed among the carpet and textile workers (Table III). Lesser excesses were found for several other sites, including esophageal cancer (PCMR = 1.5), bladder cancer (PCMR = 1.2), and thyroid cancer (2 observed, 0.5 expected). The lymphocytic leukemia excess is present among decedents in both year-of-death strata and among those dying at different ages (Table IV). An even greater lymphocytic leukemia excess was present among decedents classified as likely production workers (PCMR = 4.2, 95% CI = 1.7-8.7), but no excess of this site was seen among other residents of the five-county area (PCMR = 1.0, 95% CI = 0.5-1.9). The PCMR for genital (nonprostatic) cancer was 2.3 (95% CI = 0.3-8.8) for those most likely to have worked in production and 0.5 (95% CI = 0.1-1.7) for the remainder of the white male population of the five-county area. There were too few observations to investigate age-at-death or year-of-death subgroups for this cause of death. All five genital cancer deaths were due to testicular cancer. The PCMR for testicular cancer alone among carpet/textile workers (calculated post hoc) was 3.2

TABLE III. Observed and Expected Deaths among Carpet and Textile Workers by Cancer Site

Cancer site	Observed	Expected
Esophagus	1	0.7
Stomach	0	0.1
Small intestine	0	0.1
Colon	0	0.1
Rectum	0	0.1
Liver and gallbladder	0	0.1
Pancreas	0	0.1
Peritoneum & retroperitoneum	0	0.1
Other digestive sites	0	0.1
Larynx	0	0.1
Lung	0	0.1
Bone	0	0.1
Skin	0	0.1
Prostate	0	0.1
Genital (nonprostatic)	5	2.2
Bladder	2	1.6
Kidney	0	0.1
Brain & CNS	0	0.1
Thyroid	2	0.5
Non-Hodgkin's lymphoma	1	0.5
Hodgkin's disease	0	0.1
Multiple myeloma	0	0.1
All leukemias	1	0.5
Lymphocytic	1	0.5
Myeloid and myelodysplastic	0	0.1
Other unspecified	0	0.1
Other unspecified sites	0	0.1
All sites combined	1	0.5

TABLE IV. Observed and Expected Deaths among Carpet and Textile Workers by Year of Death and Age at Death

Year of death	Observed	Expected
1970-1978	1	0.5
1979-1984	1	0.5
Age at death (years)	Observed	Expected
20-49	1	0.5
50-64	1	0.5
65-74	0	0.1

(95% CI = 1.7-8.7) decedents expected.

The observed excess of deaths from lymphocytic leukemia demonstrates that many deaths occurred among

TABLE III. Observed and Expected Numbers of Cancer Deaths Among Northern Georgia Carpet and Textile Workers and Proportionate Cancer Mortality Ratios, by Site

Cancer site	ICD-9 codes	Observed	Expected	PCMR	95% CI
Lip, oral cavity, & pharynx	140-149	8	10.2	0.8	0.4-1.5
Esophagus	150	10	6.8	1.5	0.7-2.7
Stomach	151	9	8.1	1.1	0.5-2.1
Small intestine	152	1	0.5	—	—
Colon	153	16	20.6	0.8	0.5-1.3
Rectum	154	2	4.2	—	—
Liver and gallbladder	155-156	6	5.6	1.1	0.4-2.4
Pancreas	157	18	16.1	1.1	0.7-1.8
Peritoneum & ill-defined digestive sites	158-159	1	0.8	—	—
Larynx	161	5	4.6	1.1	0.4-2.6
Lung	162	138	140.3	1.0	0.9-1.1
Bone	170	2	1.2	—	—
Skin	172-173	5	7.6	0.7	0.2-1.6
Prostate	185	17	16.3	1.0	0.6-1.7
Genital (nonprostatic)	186-187	5	1.8	2.7	0.9-6.3
Bladder	188	8	6.5	1.2	0.6-2.5
Kidney	189	6	6.8	0.9	0.4-2.0
Brain & CNS	191 to 192	7	10.7	0.7	0.3-1.4
Thyroid	193	2	0.5	—	—
Non-Hodgkin's lymphomas	200, 202	6	8.5	0.7	0.3-1.6
Hodgkin's disease	201	3	2.9	—	—
Multiple myeloma	203	3	4.1	—	—
All leukemias	204-208	19	12.7	1.5	0.9-2.4
Lymphocytic	204	10	3.4	2.9	1.4-5.4
Myeloid and monocytic	205-206	6	6.7	0.9	0.4-2.0
Other/unspecified	207-208	3	2.7	—	—
Other/unspecified sites	194-199, 210-239	34	30.1	1.1	0.8-1.6
All sites combined	140-208, 210-239	331	331.0	1.0	—

TABLE IV. Observed and Expected Numbers of Deaths from Lymphocytic Leukemia Among Northern Georgia Carpet and Textile Workers, by Age at Death and Year of Death

	Observed	Expected
Year of death		
1970-1978	4	1.6
1979-1984	6	1.8
Age at death (years)		
20-49	2	0.7
50-64	2	1.4
65-74	6	1.4

(95% CI = 1.0-7.5). PCMRs based on the second comparison group (Atlanta area decedents excluded) were virtually identical with those shown in Table III.

The occupational and industry statements for carpet and textile workers who died of lymphocytic leukemia or testicular cancer are listed in Table V. This list demonstrates the vagueness of the occupational and industry statements found on many death certificates and fails to link any specific job titles with the excess deaths.

the following conditions:

1. *Conducting a business*
 2. *Conducting a business*

our responsibilities
other Americans
and we should

100 pue astasip

sal pinox qirap
noo pue astasip

to spurious exposure, more likely than underascertainment. Previous studies by the International Agency for Research on Cancer (IARC) (1) and by the National Institute for Occupational Safety and Health (NIOSH) (2) have found that the incidence of lung cancer is higher in men than in women who are exposed to asbestos. This is true even when the women are exposed to asbestos for longer periods of time than the men. The reason for this is not clear, but it may be related to differences in the way that men and women are exposed to asbestos. For example, men are more likely to work in jobs that involve direct contact with asbestos, while women are more likely to work in jobs that involve indirect contact with asbestos, such as cleaning or maintenance work. This difference in exposure may lead to differences in the way that asbestos is absorbed by the body, which could explain the higher incidence of lung cancer in men.

tested multiple hypotheses, which makes interpreting individual statistical tests more difficult.

Several cancer sites for which we found no unusual mortality deserve comment. Canadian workers making polypropylene carpet fiber have shown an excess of bowel cancer [Vobecky et al., 1984]. Because polypropylene extrusion is a small part of the Georgia carpet industry [Hoover Home Institute, 1983], our failure to find a similar excess is not surprising. Hoar and Blair [1984] likewise found no excess of colon cancer among textile workers in a case-control study conducted in seven South Carolina counties with carpet mills. We found no appreciable excesses of nasal, laryngeal, or lung cancers or non-Hodgkins lymphomas, which have been noted in other studies of the textile industry [Malke et al., 1986; Brinton et al., 1985; Flanders et al., 1984; Delzell and Grufferman, 1983; Kabat and Wynder, 1984]. There may be several reasons for this. First, processes used to manufacture finished carpet are different from those used in other parts of the textile industry, such as in fabric, fiber, or garment manufacture. Second, our study does not have sufficient power to detect small excesses occurring in a subgroup of the study population. Finally, the previously mentioned misclassification of exposure and disease inherent in death certificate studies makes detecting small differences difficult.

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APPENDIX I. USED IN STUDY Carpet/Textile

Usual in
a carpet or te

Occupation
Likely i
machine oper.
yarn departme
Possibly
machine fixe
quality contr
fitter, inspect
Unlikel
tant, busines
clerk, boiler
shopping dep

Persons Who Died of

Occupation/Industry

textile
 looper/textile
 style cotton mills/textile
 machine operator/textile
 sewing operator/textile
 master cotton mill
 general laborer/carpet
 textile worker —
 machine operator/textile
 style carpet
 supervisor/textile
 laundry operator/textile
 style worker/textile
 looper/textile
 style/carpet
 leukemia, CLL = chronic

chronic lymphocytic
 leukemia, and two deaths
 of choriocarcinoma.
 These were all among
 bladder cancer were all
 testicular cancer or

lymphocytic leukemia
 textile industry. The
 men. This finding is
 the industry before
 significance. Also,
 more than white collar
 possibility that this
 dismissed, as the
 factors to hypothesize

leukemia suggests an
 occupational
 may be due to a
 misclassification of
 for all leukemias

combined among carpet and textile workers is 1.5. Occupationally linked lymphocytic leukemia has been reported among rubber industry workers [Checkoway et al., 1984]. One process in the carpet industry involves the application of a secondary carpet backing, which often contains a synthetic (styrene butadiene) rubber [Hoover Home Institute, 1983]. Unfortunately, the death certificate occupational statements of the men who died of lymphocytic leukemia are not specific enough to address this hypothesis. Further work is needed to investigate the possibility that this excess is the result of workplace exposures, and, if it is, whether these hazards are currently present in carpet manufacturing plants.

Esophageal cancer was modestly elevated (PCMR = 1.5) among the carpet-textile workers. We know of no previous reports of esophageal cancer in related industries. We also found a slight excess (PCMR = 1.2; 95% CI = 0.6-2.5) of bladder cancer in this group of decedents. Bladder cancer has been found to be increased among employees in the dye industry [Cartwright, 1982] and in some groups of textile workers [Schoenberg et al., 1984], but not in others [Anthony and Thomas, 1970]. Synthetic dyes are used in the carpet industry, but this small excess could easily be due to chance. We also discovered an excess of thyroid cancer, as did Delzell and Grufferman [1983] in their study of female textile workers in North Carolina. Our result, however, is based on only two observed deaths.

The limitations of proportionate mortality analyses are well known, but these studies can be valuable for surveillance and generating hypotheses. A proportionate mortality ratio (PMR) is not rate-based and will only equal the cause-specific standardized mortality ratio (SMR) when the death rates for all causes are equal for index and referent groups [Decoufle et al., 1980]. Working populations generally have lower mortality rates than the general population, especially for nonmalignant chronic diseases [McMichael, 1976], so cause-specific PMRs for occupational groups may overestimate the corresponding SMRs. Because this "healthy worker effect" is less apparent for malignant diseases, the PCMR is less prone to this source of bias than is the PMR. Still, the PCMR may overestimate the SMR if the total cancer mortality rate of the carpet and textile workers is less than that of the comparison population.

More important limitations of this study are the possible misclassification of disease and occupation on death certificates. Random misclassification of cause of death would lessen true associations, whereas nonrandom misclassification could lead to spurious excesses if, given the same disease state, carpet and textile workers are more likely than others to be assigned certain diagnoses as cause of death. We have also limited our definition of disease to the underlying cause of death, so we may have underascertained less lethal forms of cancer.

Previous studies have suggested that the death certificate statement corresponds to the actual usual occupation and industry only 60-70% of the time [Steenland and Beaumont, 1984; Schumacher, 1986]. Although the death certificate asks for *usual* occupation and industry, it is unclear whether that job or the most recent one is given by the informants at the time of death. This problem is further exacerbated in our study by including all textile workers in our study group. We were also limited by our inability to define specific work areas and processes, length of employment, and year of first employment. We had no information on many potential confounders, most notably smoking, alcohol use, and socioeconomic status. These potential biases may cause an overestimation or underestimation of site-specific cancer risks. We have also

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APPENDIX I. INDUSTRY/OCCUPATION CLASSIFICATION SCHEME USED IN STUDY

Carpet/Textile Industry

Usual industry was given as carpet or textile, or a company was named that was a carpet or textile manufacturer [Barnett and Callier, 1984]

Occupation

Likely involved in production Occupation given as laborer, cutter, coater, machine operator, worker, dye house department, quiller, finisher, weaver, knitter, yarn department worker

Possibly involved in production Occupation given as supervisor, foreman, machine fixer, custodian, mechanic, plant coordinator, machinist, maintenance, quality control, utility man, latex serviceman, fixer, bagger, plant engineer, steam fitter, inspector

Unlikely involved in production Occupation given as truck driver, accountant, business manager, security guard, owner, president/vice-president, salesman, clerk, boiler foreman, laboratory technician, watchman, chemist, traffic manager, shopping department worker, textile designer

Unclassifiable No occupation was given, or occupation given was unclassifiable as to likelihood of production work.

Other Industry

Industry given was a specific industry other than carpet or textile, or a company name was given that was identified by us as a noncarpet textile employer.

Industry Unknown

No industry or identifiable company given (i.e., "retired," "disabled," "never worked," "none," "self-employed," "unemployed," "laborer (no industry)").

Cross-Sectional Study of Pulmonary Function in Pollution Areas

R. Gregory Evans
Stephen M. Ayres

This study in
pulmonary func-
tion in areas of
traffic in area
administered
consecutive
vision coeffi-
cient
tested at least
expiratory vol-
umes, and in
over 20 years
the most re-
working as a
respiratory sys-
importance.

Key words: automo-

INTRODUCTION

The health
pollution have
acute air polluti-

Intense ac-
Valley of Belgi-
and London, En-
of air pollutants.

When the
episodes, there

Division of Environ-
Education and Re-
Medical College of
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C306, 1402 So. Main
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