PRELIMINARY FINDINGS OF AN EPIDEMIOLOGIC STUDY OF TALC WORKERS

John Gamble
Alice Greife
John Hancock

National Institute for Occupational Safety and Health

Appalachian Laboratory for Occupational Safety and Health

944 Chestnut Ridge Road

Morgantown, West Virginia 26505

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INTRODUCTION

Talc is a mineral with a wide variety of uses in paint, paper, ceramics, cosmetics, plastics, roofing products, textile material, rubber, lubricants, corrosion proofing composition fire extinguishing powders, cereal polishing, water filtration, insecticides to name a few. Pure talc is a hydrated magnesium silicate, but the talc found in nature has a quite variable chemical composition. The mineral contaminant in talc of most concern is asbestos, which can produce a clinical condition resembling that seen on exposure to asbestos per se. The possible hazards from exposure to talc free of asbestos contamination is less well documented. The purpose of this study was to ascertain the effects on the respiratory system (symptoms, lung function, radiographic) of exposure to talc dust thought prior to the study to contain no asbestos. Two hundred and ninety-nine talc workers mining and milling talc from Montana, Texas, and North Carolina were studied in this cross-sectional prevalence study. The mineralogy of the talc and exposure of the workers were just discussed by Ms. Greife. In this paper we will report on the chronic or long-term effects of exposure.

The specific questions addressed in this paper are: What is the prevalence of respiratory symptoms, radiographic changes and reduced lung function among these talc workers? What are the dose-response relations? How does "morbidity" of the study populations compare to that of other mining populations?

METHODS

The study population consisted of workers mining and milling talc from three regions of the United States: Montana, Texas, and North Carolina. Although several different companies may be involved, the results for each region are combined, as the characteristics of the talc in each region are similar. Over 90% of the workers participated in the study.

All workers were administered a British Medical Research Council respiratory questionnaire by trained interviewers. Most of the interviews in Texas were conducted in Spanish. Non-talc work history was obtained in the interview; work experience at the talc facility was obtained from company records. Standard posteroanterior chest radiograms were read by three "B" readers using the ILO U/C 1971 scheme. The films were read independently without knowledge of age, occupation, or smoking history. The median of the three readings was used for analysis. Flow volume curves from a minimum of 5 forced maneuvers were obtained and recorded on magnetic tape using an Ohio 800 rolling seal spirometer. Values from the maximum envelope were used for analysis. Before and after shift spirometry was administered to workers on the day shift, and personal environmental samples were also collected on these workers. The results of the personal environmental sampling were used to evaluate (1) dose-response relations of talc dust with acute changes in pulmonary function over the shift (ΔPFT = after shift PFT minus before shift PFT); and (2) estimate talc dust exposure for each job. This estimate was then used to calculate cumulative talc dust exposure by multiplying job exposure by job years to nearest month, and adding the results of each multiplication. The units for cumulative exposure are mg/m^3 x years (mg/m^3-years). Sputums were collected on workers 35 years or older.

The prevalence of symptoms and pleural thickening were compared to 3 mining populations, after indirect adjustment for smoking, and using the age distribution of all populations.

Internal comparisons of prevalence and dose-response relationships will be examined first (Tables 5-14). Then comparisons with external control populations will be made (Tables 16-18). Dose-response relationships and external comparisons for lung function are in Tables 19-21.

RESULTS

All of the Texas talc workers were male, while about 20% of the Montana and North Carolina talc workers were female. The North Carolina population had the highest proportion of smokers (62%) and lowest proportion of ex-smokers (17%). The highest proportion of nonsmokers (33%) and lowest proportion of smokers (46%) were in Montana. Cigarettes smoked per day was similar among smokers and ex-smokers in North Carolina and Montana (approximately a pack a day), but was 1/3 a pack a day less in Texas. The North Carolina population had worked on average about 3 1/2 years longer (10 years) than the workers in Montana (7 years) and Texas (6 years), but cumulative exposure in North Carolina was one-half (3 mg/m^3-years) that of Montana workers (6 mg/m^3-years) and about 1/4 that of Texas workers (11 mg/m^3-years) (Table 1). Average exposure (cumulative exposure divided by years worked) showed the same ranking.

Only 11% of the workers in Montana and Texas had worked 10 or more years compared to 38% in North Carolina. Most of the study population in Montana and Texas had worked less than 5 years (66% and 73% respectively).

About 20% in all regions had worked from 5-9 years. North Carolina had the lowest cumulative exposure in each years worked category, especially in the less than 10 years category. The men working 5-9 years in Texas had the highest mean cumulative exposure of any group (25 mg/m^3-years); twice that of the next highest group of Montana workers with 10 or more years tenure (12 mg/m^3-years). Age, years worked, and cumulative exposure were correlated enough to potentially confound any dose-response association.

Table 3 summarizes the characteristics of the low, medium, and high cumulative exposure groups by region. North Carolina had a higher proportion of workers in the low exposure group and a lower proportion in the medium and high exposure groups. The North Carolina population was older and had more years exposure in each cumulative exposure group. Mean cumulative exposure was also lowest in the low and high exposure group from North Carolina. The Montana and Texas populations were generally similar except for the very high mean cumulative exposure (40 mg/m^3-years) in the Texas high exposure group. Smokers comprised about 50% of all exposure groups except for the medium exposure group from North Carolina where 90% were smokers.

Table 4 summarizes by region the frequency of working in non-talc jobs where exposure to respiratory irritants was possible. The frequency was generally low and similar in each region.

There were only 2 cases of pneumoconiosis, both grade 1 small rounded opacities in Texas and Montana. This number is too small to analyze further.

Cytology on sputums collected from workers greater than or equal to 35 years of age revealed no cytology suggestive of malignancy.

Tables 5-14 summarize the prevalence of cough, phlegm, shortness of breath, pleural thickening, and obstruction by region, smoking, and exposure. The overall prevalence of cough was 18%, 17%, and 27% in Montana, Texas, and North Carolina. Cough increased with age in all smoking groups in Montana and in the nonsmoking and ex-smoking category in Texas. No increase with age was observed in North Carolina. Smokers had a higher prevalence of cough than nonsmokers and ex-smokers in Montana, and a higher prevalence than nonsmokers in North Carolina (Table 5). The only statistically significant difference was between smokers and ex-smokers in Montana. Cough showed no apparent association with either years worked or with cumulative exposure, although the medium exposure group had a higher prevalence than the low exposure group (Table 6).

The overall prevalence of phlegm was 18%, 17%, and 25% in Montana, Texas, and North Carolina. Phlegm did not increase with age in Montana (all smoking categories), Texas (nonsmokers and smokers), or nonsmokers in North Carolina. Among smokers in North Carolina and ex-smokers in Texas, phlegm increased with age. Smokers had a higher prevalence of phlegm than nonsmokers in Montana and North Carolina; ex-smokers were intermediate. Ex-smokers had the highest prevalence in Texas, and nonsmokers were intermediate (Table 7). None of these differences were statistically significant. There was no consistent tendency for the prevalence of phlegm to increase with years worked. In Texas and North

Carolina (but not Montana), the prevalence of phlegm increased with increasing cumulative exposure (but was not statistically significant) (Table 8).

The prevalence of dyspnea was low compared to cough and phlegm with 4%, 9%, and 6% in Montana, Texas, and North Carolina complaining of shortness of breath when walking on level ground with people their own age. The rates increased with age in all smoking groups and regions (except smokers in North Carolina where prevalence was zero). There was no apparent association of dyspnea with smoking, however. Smokers often had the lowest prevalence of dyspnea (Table 9). No differences were statistically significant. There was no consistent increase with increasing years worked (there was no dyspnea in any region among the 5-9 year tenure group). In North Carolina the prevalence was elevated in the high cumulative exposure group compared to the low cumulative exposure, but the difference was not statistically significant (Table 10).

The overall prevalence of pleural thickening was 4%, 13%, and 18% in Montana, Texas, and North Carolina. Pleural thickening increased with increasing age in all regions but was significant only in Texas. Nonsmokers had the lowest prevalence (only one nonsmoker had pleural thickening), while the prevalence among smokers and ex-smokers was similar (Table 11). Prevalence of pleural thickening increased slightly with increasing years worked, but did not increase with increased cumulative exposure (Table 12).

The overall prevalence of obstruction ($FEV_1/FVC < .70$) was 18%, 13%, and 23% in Montana, Texas, and North Carolina. The prevalence of obstruction

increased with age in all regions and smoking categories, but was significant only among nonsmokers, smokers, and total in Montana and total in North Carolina. Smokers had a higher prevalence than nonsmokers, but only in Montana, and the differences were not statistically significant (Table 13). There was no apparent association with cumulative exposure or years worked (Table 14).

Tables 16 through 18 compare adjusted prevalence of symptoms, pleural thickening, and obstruction of the talc population with 3 mining populations: 878 potash miners, 503 coal workers who had never worked underground, and 7942 coal miners who had worked only underground. The potash miners were part of a MSHA/NIOSH study.[1,2] The coal workers are from the second round of the National Coal Workers Study. Demographic characteristics of these populations are summarized in Table 15.

The adjusted rate of cough among underground coal miners was higher overall and in the 40 year or older age group compared to potash, aboveground coal and talc workers. There was little difference in the prevalence rates among these latter groups and no detectable difference among the talc regions in both age categories. Phlegm showed a somewhat similar pattern except the underground coal miners had more phlegm in both age groups. Again the talc groups showed no detectable difference from each other. Montana had a lower prevalence than aboveground coal workers in the older age category (Table 16).

The overall prevalence of dyspnea was significantly higher in the underground coal miners (24%) than all other populations. All the other

populations had rates ranging from 5% (Montana) to 14% (aboveground coal). Rates in the 40 or more year group were 7-15% compared to 28% and 41% in the coal populations. In the less than 40 year old group underground coal was again high with 10%, while all other population rates were 5% or less (Table 17).

Pleural thickening was elevated in the talc populations compared to the comparison populations. Prevalence was elevated in the younger talc workers, but only the increase in North Carolina was statistically significant. Montana had the lowest prevalence of pleural thickening among the talc populations, but the differences were not significant (Table 17).

There were no detectable differences in the prevalence of obstruction among any of the populations (Table 18).

Table 19 summarizes the results of multiple regression models of pulmonary function (FEV_1, FVC, Peak Flow, FEF_{50}, FEF_{75}) with the predictor variables sex, mine, age, height, pack years and cumulative exposure. Sex, age, and height were significant variables for FEV_1, FVC, and peak flow. Of these 3 variables, only age significantly reduced the variability in flow rates (FEF_{50}, FEF_{75}). Pack years was generally significant for FEV_1 and flow rates, but not for FVC. Mine, region, and cumulative exposure were not significant.

Essentially the same results occur when the class variables smoking status and cumulative exposure group replace the continuous variables pack years and cumulative exposure. Adjusted mean values by smoking status, region, and cumulative exposure group are summarized in Table 20.

In Table 21, pulmonary function of the combined male talc populations is compared to the control populations (after adjustments for age, height, and smoking). FEV_1, FVC, and flow rates at low lung volumes (FEF_{50}, FEF_{75}) were reduced compared to the coal populations. Peak flow was about the same as underground coal, and elevated compared to aboveground coal. When compared to potash miners, flow rates were reduced, but there was no detectable difference in FEV_1 and FVC.

DISCUSSION

Interpretation of the data from this study has the inherent problems of all cross-sectional prevalence studies. These include the lack of any past environmental measures so cumulative exposure is based on current exposure levels only. In addition the numbers of workers in North Carolina and Texas was small, especially after stratification. The small numbers result in very wide confidence intervals. Exposure time (years worked) was short compared to other mining populations. The mean years worked for the potash and coal populations was 16, 18, and 15 years compared to 6, 7, and 10 years for the talc populations. This is a short time for the development of chronic symptoms, pneumoconiosis and impaired pulmonary function caused by work exposure.

None of the health variables were consistently or strongly related to the exposure variables (years worked, cumulative exposure). Cumulative exposure is only a crude estimate of past exposures, based on current levels taken over a short time period. Since past environmental measures

were not taken, past exposures for each job were assumed (for the purposes of calculation) to be the same as current exposures. Thus cumulative exposure is only an estimate, and how much season of the year, changes in the talc composition, humidity, and other factors affect this estimate are not known.

Age was consistently associated with increased prevalence of cough, dyspnea, pleural thickening, and decreased pulmonary function. The calculated loss of pulmonary function with age was comparable to values from other cross-sectional studies,[3-5] and there was little difference in the age coefficients among the regions. Except for FVC and FEF_{50}, mean adjusted pulmonary function values were not statistically different among the regions. Mean FVC was largest in the Montana population and least in Texas. The rank order for FEF_{50} was reversed. FVC was reduced in the high exposure group, but the reduction was not large. The high exposure group did not have the lowest value for any of the other lung function parameters. The reductions in lung function compared to the coal populations (particularly FEV_1 and FVC) were not large. It is interesting that lung function was reduced compared to the coal populations, despite their higher prevalence of respiratory symptoms. The relationship between smoking and pulmonary function was as might be expected. Smokers generally had the poorest values, and nonsmokers the best.

Thus there were no apparent dose-response relationships with symptoms or lung function, and no apparent excess symptoms or large reductions in lung function compared to the control populations. This does not mean that

talc may not have an effect on these health parameters. A dose-response relation can be obscured by an inaccurate estimate of exposure. And the comparison populations used in this report were exposed to respiratory irritants (e.g., coal dust, diesel fumes, sylvite or KCl and NaCl), thereby possibly increasing the prevalence of symptoms and reducing lung function. Comparison with a blue collar "nonexposed" population is now underway and will be reported elsewhere.

The same criticism regarding the comparison populations may not be valid for pleural thickening, which was quite low in all the non-talc populations. The pleural thickening was associated with years worked (somewhat confounded with age). But the increased prevalence occurred in all 3 regions, despite the difference in exposure, and difference in talc composition.

In this study age and years worked were associated with an increase of pleural thickening, although one worker with pleural thickening was in the 20-29 year age category, and 4 in the 30-39 year age group. Three of these had worked 5 years or less. While pleural calcification is rare in individuals under 40, uncalcified plaques are "quite often" seen in individuals less than 40.[6] Ochs and Smith[7] report on several cases where as little as a years time interval was necessary for the appearance of pleural thickening.

Asbestos (particularly anthophyllite) from either occupational or community exposure is believed to cause an increased prevalence of pleural thickening.[8] Talc contaminated with asbestos (tremolite and anthophyllite) as seen under the light microscope and EM has also been associated

REFERENCES

1. Attfield, M: The effect of exposure to silica and diesel exhaust in underground metal and nonmetal miners. Industrial Hygiene for Mining and Tunneling - Proceedings of an ACGIH Topical Symposium. November 6-7, 1978.

2. Sutton, GW, Weems, GW, Schutz, LA, Trabant, GD: Summary report of the environmental results of the MSHA/NIOSH Silica/Diesel exhaust study. Industrial Hygiene for Mining and Tunneling - Proceedings of an ACGIH Topical Symposium, November 6-7, 1978.

3. Morris, JF, Koski, A and Breese, JD: Normal values and evaluation of forced end - expiratory flow. Am Rev Resp Dis., 111:755-762, 1975.

4. Bass, H: The flow-volume loop. Chest, 63:171-176, 1973.

5. Ashford, JR, Brown, S, Morgan, DC, and Rae, S: The pulmonary ventilatory function of coal miners in the United Kingdom. Am Rev Resp Dis., 97:810-926, 1967.

6. Fletcher, DE and Edge, JR: The early radiological changes in pulmonary and pleural asbestosis. Radiol., 21:355-365, 1970.

7. Ochs, CW and Smith, JP: Chronic pleural thickening: Some observations on cause and pathogeneses. Military Med., 141:77-81, 1976.

8. Sargent, EN, Jacobson, G, and Gordonson, JS: Pleural Plaques: A signpost of asbestos dust inhalation. Seminars in Roentgenology, 12:287-297, 1977.

9. Gamble, JF, Fellner, W, and DiMeo, MJ: An epidemiologic study of a group of talc workers. Am Rev Resp Dis., 119:741, 1979.

10. Dement, JM and Zumwalde, RD: Occupational exposures to talcs containing asbestiform minerals in Dusts and Disease, Lemen, R, and Dement, JM (eds). Pathotox Publishers, Inc., Park Forest South, Illinois, 1979.

11. Rubino, CF, Scansetti, G, Piolatto, G, Gay, G: Mortality and morbidity among talc miners and millers in Italy. Institute of Occupational Health of Turin University, 1977, 12 pages.

12. Delaude, A: Talc-related pathology. Bull Acad Nat Med., 161:405-409, 1977.

13. Messite, J, Reddin, G, Kleinfeld, M: Pulmonary Talcosis, a clinical and environmental study. Arch Ind Hlth., 20:408-413, 1959.

14. Fine, LJ, Peters, MJ, Burgess, WA, DiBerardinis, LJ: Studies of respiratory morbidity in rubber workers. Part IV. Respiratory Morbidity in Talc Workers. Arch Env Hlth., 31:195-200, 1976.

15. Wegmen, DH, Burgess, WA, and Peters, MJ: Talc Workers Health Study Report. Harvard School of Public Health, unpublished paper.

16. Meurman, LO: Pleural fibrocalcific plaques and asbestos exposure. Env Res., 2:30-46, 1968.

TABLE 1

DEMOGRAPHIC CHARACTERISTICS OF THE TALC WORKER POPULATIONS BY REGION

		MONTANA	TEXAS	NORTH CAROLINA
n		177	71	51
AGE	(S.D.)	34.9 (11.5)	38.0 (13.7)	43.1 (12.6)
HEIGHT	(S.D.)	175.5 (8.8)	173.0 (6.9)	172.5 (8.3)
WEIGHT	(S.D.)	77.8 (13.5)	78.3 (15.1)	78.2 (16.3)
YEARS WORKED	(S.D.)	6.6 (6.3)	5.5 (5.7)	10.1 (8.6)
CUMULATIVE EXPOSURE	(S.D.)	5.9 (7.6)	11.3 (45.1)	3.0 (4.8)
AVERAGE EXPOSURE (mg/m^3)	(S.D.)	1.21 (.94)	2.64 (7.12)	0.28 (0.33)
NONSMOKERS	(%)	33	20	21
EX-SMOKERS	(%)	21	27	17
PACK YEARS	(S.D.)	15.7 (17.9)	13.3 (20.7)	18.2 (16.5)
CIGARETTES/DAY	(S.D.)	23 (15)	12 (14)	21.4 (15.7)
SMOKERS	(%)	45	54	62
PACK YEARS	(S.D.)	17.9 (16.9)	14.3 (19.7)	23.7 (21.8)
CIGARETTES/DAY	(S.D.)	20.4 (11.0)	14.5 (11.1)	20.4 (10.0)

TABLE 7

A. CHARACTERISTICS OF TALC WORKERS BY REGION AND YEARS WORKED CATEGORIES

		AGE	YEARS WORKED	CUMULATIVE EXPOSURE	AVERAGE EXPOSURE
	n	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)
MONTANA					
5	92	28.6 (8.8)	1.9 (1.3)	2.3 (2.4)	1.47 (1.01)
5-9	39	36.5 (10.4)	7.2 (1.5)	7.3 (6.1)	1.05 (0.87)
≥10	46	46.2 (7.8)	15.4 (4.9)	12.0 (10.7)	0.84 (0.67)
TEXAS					
5	39	34.8 (14.1)	1.6 (1.3)	4.4 (11.5)	3.02 (7.45)
5-9	21	39.6 (13.3)	6.7 (1.6)	24.9 (80.8)	2.98 (8.32)
≥10	11	46.5 (9.2)	16.6 (4.6)	9.8 (11.1)	0.64 (0.71)
NORTH CAROLINA					
5	19	35.3 (13.8)	1.6 (1.8)	0.52 (1.22)	0.25 (0.32)
5-9	6	43.8 (12.0)	7.2 (1.2)	0.47 (0.32)	0.07 (.05)
≥10	26	48.6 (8.6)	17.1 (6.0)	5.3 (5.8)	0.34 (.36)

B. CORRELATION OF AGE, YEARS WORKED, AND CUMULATIVE EXPOSURE BY REGION

r (95% C.I.)

	MONTANA	TEXAS	NORTH CAROLINA
AGE BY YEARS EXPOSED	.63 (.48 to .78)	.36 (.12 to .48)	.51 (.23 to .79)
AGE BY CUMULATIVE EXPOSURE	.41 (.26 to .56)	.12 (-.12 to .36)	.33 (.05 to .61)
YEARS EXPOSURE BY CUMULATIVE EXPOSURE	.48 (.33 to .63)	.12 (-.12 to .36)	.44 (.16 to .72)

TABLE 3

CHARACTERISTICS OF TALC WORKERS EXPOSURE GROUPS BY REGION

		n	AGE	YEARS WORKED	CUMULATIVE EXPOSURE	AVERAGE EXPOSURE
		n (%)	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)
MONTANA	LOW	54 (31)	33.4 (10.5)	5.6 (7.4)	0.48 (0.33)	0.54 (0.81)
	MEDIUM	64 (36)	32.0 (11.4)	4.0 (4.3)	2.72 (1.38)	1.44 (1.01)
	HIGH	59 (33)	39.3 (11.5)	10.3 (5.2)	14.4 (7.7)	1.57 (.58)
TEXAS	LOW	27 (38)	33.3 (13.1)	4.9 (7.0)	0.37 (0.30)	0.57 (0.70)
	MEDIUM	26 (37)	40.2 (13.6)	4.2 (3.8)	2.93 (1.48)	1.09 (0.71)
	HIGH	18 (25)	42.1 (13.4)	8.1 (5.4)	39.9 (84.9)	7.98 (12.91)
NORTH CAROLINA	LOW	32 (63)	40.6 (13.7)	7.5 (8.0)	0.30 (0.29)	0.11 (0.19)
	MEDIUM	10 (20)	44.3 (8.5)	13.5 (9.7)	3.53 (2.12)	0.38 (0.30)
	HIGH	9 (18)	50.6 (9.4)	15.9 (4.9)	11.8 (4.7)	0.75 (0.24)

LOW CUMULATIVE EXPOSURE = <2 mg/m^3 -years

MEDIUM CUMULATIVE EXPOSURE = 2 - 5.9 mg/m^3 -years

HIGH CUMULATIVE EXPOSURE = $\geq$6 mg/m^3 -years

AVERAGE EXPOSURE = Σ(cumulative exposure/years worked)

TABLE 4

PREVALENCE (%) BY REGION OF OTHER OCCUPATIONS

	MONTANA n	(%)	TEXAS n	(%)	NORTH CAROLINA n	(%)
HAVE YOU EVER WORKED						
IN A QUARRY?	3	(1.7)	2	(2.8)	6	(11.8)
IN A FOUNDRY?	2	(1.1)	0		0	
IN A POTTERY?	2	(1.1)	1	(1.4)	0	
IN A COTTON, FLAX, OR HEMP MILL?	1	(0.6)	13	(18.3)	4	(7.8)*
WITH ASBESTOS?	4	(2.3)	1	(1.4)	0	

*95% confidence intervals do not overlap.

TABLE 5

PREVALENCE OF COUGH AMONG TALC WORKERS BY AGE, SMOKING, AND REGION

	AGE					
	40		≥40		TOTAL	
	%	(95% C.I.)	%	(95% C.I.)	%	(95% C.I.)
MONTANA						
NONSMOKER	7	(6 - 19)	19	(5 - 42)	10	(4 - 21)
EX-SMOKER	0	(0 - 16)	10	(2 - 28)	5	(1 - 17)*
SMOKER	27	(16 - 40)	38	(19 - 58)	29	(19 - 40)*
TOTAL	16	(10 - 24)	23	(13 - 35)	18	
TEXAS						
NONSMOKER	10	(1 - 40)	25	(1 - 75)	14	(3 - 39)
EX-SMOKER	11	(1 - 44)	40	(15 - 73)	26	(11 - 50)
SMOKER	15	(6 - 34)	8	(0 - 35)	13	(5 - 28)
TOTAL	13	(5 - 28)	23	(11 - 42)	17	(9 - 28)
NORTH CAROLINA						
NONSMOKER	0	(0 - 50)	0	(0 - 40)	0	(0 - 25)
EX-SMOKER	33	(2 - 87)	17	(1 - 60)	22	(4 - 56)
SMOKER	38	(17 - 67)	37	(15 - 64)	38	(21 - 58)
TOTAL	29	(13 - 51)	26	(12 - 45)	27	

COUGH = Answering yes to the question: "Do you usually cough on most days for as much as three months each year?"

SUMMARY: Increase with age except in North Carolina and among smokers in Texas.

Smokers had highest prevalence except among 40 or more year old smokers in Texas. Association with ex-smokers variable. Only significant differences was between smokers and ex-smokers in Montana.

* 95% confidence intervals do not overlap.

TABLE 6

PREVALENCE OF COUGH BY EXPOSURE AND REGION

	MONTANA % (95% C.I.)	TEXAS % (95% C.I.)	NORTH CAROLINA % (95% C.I.)
YEARS WORKED			
5	17 (11 - 25)	20 (10 - 35)	30 (14 - 53)
5-9	14 (6 - 30)	18 (3 - 50)	33 (12 - 65)
≥10	30 (9 - 36)	0 (0 - 32)	20 (7 - 41)
CUMULATIVE EXPOSURE			
LOW (2)	15 (6 - 28)	7 (1 - 22)	19 (9 - 36)
MEDIUM (2-6)	17 (9 - 28)	31 (15 - 51)	50 (22 - 78)
HIGH (_6)	17 (9 - 29)	11 (2 - 33)	22 (4 - 56)

COUGH = Answering yes to the question: "Do you usually cough on most days for as much as three months each year?"

SUMMARY: No consistent tendency to increase with increasing years worked.

No tendency for prevalence to increase with increasing cumulative exposure.

No statistically significant association with either exposure variable.

TABLE 7

PREVALENCE OF PHLEGM AMONG TALC WORKERS BY AGE, SMOKING, AND REGION

	40 % (95% C.I.)	≥40 % (95% C.I.)	TOTAL % (95% C.I.)
MONTANA			
NONSMOKER	12 (4 - 27)	6 (0 - 25)	10 (4 - 21)
EX-SMOKER	17 (5 - 38)	14 (4 - 34)	10 (6 - 30)
SMOKER	27 (17 - 40)	23 (13 - 50)	26 (16 - 36)
TOTAL	20 (13 - 29)	17 (8 - 29)	18
TEXAS			
NONSMOKER	20 (6 - 50)	25 (1 - 75)	21 (6 - 50)
EX-SMOKER	22 (4 - 56)	40 (15 - 73)	32 (15 - 57)
SMOKER	8 (1 - 24)	8 (0 - 35)	8 (2 - 21)
TOTAL	14 (5 - 29)	23 (11 - 39)	17
NORTH CAROLINA			
NONSMOKER	0 (0 - 50)	0 (0 - 40)	0 (0 - 25)
EX-SMOKER	0 (0 - 63)	33 (6 - 73)	22 (4 - 56)
SMOKER	23 (7 - 52)	42 (22 - 66)	34 (18 - 54)
TOTAL	14 (4 - 34)	32 (16 - 51)	25

PHLEGM = Answering yes to the question: "Do you usually bring up phlegm from your chest for as much as three months each year?"

SUMMARY: Increased prevalence with age only among both smoking categories in North Carolina; ex-smokers and nonsmokers in Texas.

Association with smoking in Montana and North Carolina. Ex-smokers highest and smokers lowest prevalence in Texas.

No statistically significant differences by age or smoking.

TABLE 8

PREVALENCE OF PHLEGM BY EXPOSURE AND REGION

	MONTANA % (95% C.I.)	TEXAS % (95% C.I.)	NORTH CAROLINA % (95% C.I.)
YEARS WORKED			
5	19 (13 - 27)	20 (10 - 34)	20 (7 - 41)
5-9	12 (4 - 26)	9 (6 - 37)	33 (12 - 65)
10	30 (14 - 53)	13 (1 - 50)	25 (10 - 47)
CUMULATIVE EXPOSURE			
LOW (2)	17 (8 - 30)	7 (1 - 22)	13 (5 - 29)
MEDIUM (2-6)	18 (9 - 30)	27 (11 - 64)	50 (22 - 78)
HIGH (6)	17 (8 - 30)	17 (5 - 38)	33 (10 - 71)

PHLEGM = Answering yes to the question: "Do you usually bring up phlegm from your chest for as much as three months each year?"

SUMMARY: No consistent tendency to increase with years worked.

Higher prevalence in Medium and High Exposure groups in Texas and North Carolina, but not statistically significant.

TABLE 9

PREVALENCE OF DYSPNEA AMONG TALC WORKERS BY AGE, SMOKING, AND REGION

	AGE		
	40	≥40	TOTAL
	% (95% C.I.)	% (95% C.I.)	% (95% C.I.)
MONTANA			
NONSMOKER	2 (1 - 19)	6 (0 - 25)	3 (0 - 11)
EX-SMOKER	6 (0 - 24)	10 (2 - 28)	8 (2 - 21)
SMOKER	2 (0 - 9)	5 (0 - 21)	2 (0 - 8)
TOTAL	2 (0 - 6)	7 (2 - 16)	4
TEXAS			
NONSMOKER	10 (1 - 40)	25 (1 - 75)	14 (3 - 39)
EX-SMOKER	0 (0 - 29)	20 (4 - 60)	11 (2 - 32)
SMOKER	0 (0 - 12)	8 (3 - 45)	5 (0 - 16)
TOTAL	2 (0 - 12)	19 (8 - 37)	9
NORTH CAROLINA			
NONSMOKER	0 (0 - 50)	17 (0 - 40)	9 (0 - 37)
EX-SMOKER	0 (0 - 63)	33 (6 - 73)	22 (4 - 56)
SMOKER	0 (0 - 23)	0 (0 - 15)	0 (0 - 10)
TOTAL	0 (0 - 14)	10 (3 - 24)	6

DYSPNEA = Answering yes to the question: "Do you get short of breath walking with people your own age on level ground?"

SUMMARY: Prevalence increased with age.

No association with smoking.

None of the differences were statistically significant.

TABLE 10

PREVALENCE OF DYSPNEA BY EXPOSURE AND REGION

	MONTANA % (95% C.I.)	TEXAS % (95% C.I.)	NORTH CAROLINA % (95% C.I.)
YEARS WORKED			
5	5 (3 - 12)	10 (4 - 22)	5 (0 - 22)
5-9	0 (0 - 9)	0 (0 - 25)	0 (0 - 24)
≥10	5 (0 - 22)	13 (0 - 50)	10 (2 - 29)
CUMULATIVE EXPOSURE			
LOW (2)	6 (1 - 16)	7 (1 - 22)	3 (0 - 17)
MEDIUM (2-6)	2 (0 - 7)	8 (1 - 23)	0 (0 - 27)
HIGH (_6)	3 (0 - 11)	11 (2 - 33)	22 (4 - 56)

DYSPNEA = Answering yes to the question: "Do you get short of breath walking with people your own age on level ground?"

SUMMARY: No consistent increase with increasing years worked.

No consistent increase with increasing cumulative exposure.

TABLE 11

PREVALENCE OF PLEURAL THICKENING AMONG TALC WORKERS BY AGE, SMOKING AND REGION

	AGE					
	40		≥40		TOTAL	
	%	(95% C.I.)	%	(95% C.I.)	%	(95% C.I.)
MONTANA						
NONSMOKER	0	(0 - 11)	0	(0 - 17)	0	(0 - 8)
EX-SMOKER	14	(1 - 55)	10	(2 - 29)	8	(3 - 27)
SMOKER	2	(0 - 10)	14	(4 - 34)	5	(2 - 13)
TOTAL	2	(0 - 7)	9	(3 - 19)	4	
TEXAS						
NONSMOKER	0	(0 - 27)	25	(1 - 75)	7	(0 - 31)
EX-SMOKER	13	(1 - 50)	22	(4 - 56)	18	(5 - 42)
SMOKER	0	(0 - 12)*	42	(18 - 71)*	13	(4 - 27)
TOTAL	2	(0 - 12)*	32	(15 - 52)*	13	
NORTH CAROLINA						
NONSMOKER	0	(0 - 50)	0	(0 - 50)	0	(0 - 27)
EX-SMOKER	33	(2 - 87)	33	(6 - 73)	33	(10 - 71)
SMOKER	8	(0 - 33)	28	(12 - 56)	19	(9 - 36)
TOTAL	10	(2 - 28)	24	(10 - 41)	18	

SUMMARY: Increased prevalence with increased age (significant only in Texas among smokers and combined).

No relationship with smoking (lowest prevalence in nonsmokers, highest prevalence in ex-smokers).

*95% confidence intervals do not overlap.

TABLE 12

PREVALENCE OF PLEURAL THICKENING AMONG TALC WORKERS BY EXPOSURE AND REGION

	MONTANA % (95% C.I.)	TEXAS %(95% C.I.)	NORTH CAROLINA % (95% C.I.)
YEARS WORKED			
5	3 (1 - 8)	10 (7 - 33)	15 (4 - 35)
5-9	5 (0 - 17)	18 (3 - 50)	18 (3 - 50)
≥10	11 (2 - 33)	29 (5 - 66)	21 (8 - 43)
CUMULATIVE EXPOSURE			
LOW (2)	2 (0 - 11)	4 (0 - 19)	13 (5 - 29)
MEDIUM (2-6)	2 (0 - 11)	23 (11 - 42)	10 (0 - 40)
HIGH (≥6)	7 (2 - 16)	6 (0 - 25)	--

SUMMARY: Tendency for prevalence to increase with increasing years worked.

No consistent increase with increased cumulative exposure.

TABLE 13

PREVALENCE OF OBSTRUCTION (FEV_1/FVC .70) AMONG TALC WORKERS BY AGE, SMOKING AND REGION

	AGE		
	40 % (95% C.I.)	40 % (95% C.I.)	TOTAL % (95% C.I.)
MONTANA			
NONSMOKER	2 (0 - 11)*	29 (12 - 54)*	10 (4 - 21)
EX-SMOKER	6 (0 - 25)	33 (14 - 55)	21 (10 - 36)
SMOKER	14 (6 - 25)*	45 (26 - 67)*	22 (14 - 33)
TOTAL	9 (4 - 17)*	37 (25 - 51)*	18
TEXAS			
NONSMOKER	10 (0 - 40)	50 (10 - 90)	21 (6 - 50)
EX-SMOKER	0 (0 - 50)	10 (0 - 40)	5 (0 - 22)
SMOKER	4 (0 - 19)	33 (12 - 65)	14 (5 - 30)
TOTAL	5 (1 - 17)	27 (11 - 47)	13
NORTH CAROLINA			
NONSMOKER	0 (0 - 50)	33 (6 - 73)	18 (3 - 50)
EX-SMOKER	0 (0 - 63)	33 (6 - 73)	22 (4 - 56)
SMOKER	0 (0 - 29)	39 (16 - 63)	26 (11 - 44)
TOTAL	0 (0 - 16)*	37 (21 - 56)*	23

SUMMARY: Obstruction increased with age in all smoking categories (significant in Montana nonsmokers, smokers and combined, and combined in North Carolina).

Obstruction had a tendency to be higher in smokers, but only in Montana.

*95% confidence intervals do not overlap.

TABLE 14

PREVALENCE OF OBSTRUCTION (FEV_1/FVC .70) AMONG TALC WORKERS BY EXPOSURE AND REGION

	MONTANA % (95% C.I.)	TEXAS % (95% C.I.)	NORTH CAROLINA % (95% C.I.)
YEARS WORKED			
5	15 (9 - 23)	16 (7 - 30)	17 (5 - 38)
5-9	22 (10 - 38)	9 (0 - 37)	20 (4 - 60)
10	30 (14 - 53)	0 (0 - 32)	32 (15 - 57)
CUMULATIVE EXPOSURE			
LOW (2)	28 (16 - 43)	11 (3 - 27)	23 (10 - 40)
MEDIUM (2-6)	8 (3 - 18)	15 (5 - 33)	29 (5 - 66)
HIGH (6)	17 (9 - 29)	11 (2 - 33)	22 (4 - 56)

SUMMARY: Tendency to increase with years worked in Montana and North Carolina.

No association with cumulative exposure.

TABLE 15

CHARACTERISTICS OF COMPARISON POPULATIONS FOR TALC STUDY

		POTASH	ABOVEGROUND COAL	UNDERGROUND COAL
n		875	509	5722
AGE	(S.D.)	41 (13)	44 (12)	39 (13)
HEIGHT (cm)	(S.D.)	176 (6)	175 (6)	174 (6)
YEARS WORKED (RANGE)	(S.D.)	16 (13) (0-50)	18 (13) (0-55)	15 (13) (0-56)
NONSMOKERS	(%)	20	22	21
EX-SMOKERS	(%)	28	32	23
MEAN PACK YEARS	(S.D.)	23 (20)	24 (19)	17 (18)
MEAN CIGARETTES/DAY	(S.D.)	25 (14)	23 (12)	19 (12)
SMOKERS	(%)	52	46	56
MEAN PACK YEARS	(S.D.)	28 (23)	27 (18)	17 (14)
MEAN CIGARETTES/DAY	(S.D.)	25 (12)	22 (9)	17 (8)
MEAN CURRENT NO_2 CONCENTRATION (ppm)		*0.90	N.A.	N.A.
MEAN CURRENT TOTAL DUST (mg/m^3)		*3.45	N.A.	N.A.
RESPIRABLE DUST		N.A.	1.44 ++	1.36 ++

* Personal samples, from (1,2)

N.A. = Not available.

++ Collected between the first and second rounds of the National Coalworkers' Study. The 25 coal mines were in both the first and second rounds of examinations of the coal study.

TABLE 16

COMPARATIVE RATES (%) OF COUGH AND PHLEGM AMONG TALC WORKERS COMPARED TO POTASH MINERS, ABOVEGROUND AND UNDERGROUND COAL MINERS, STRATIFIED BY AGE AND INDIRECTLY ADJUSTED FOR SMOKING.

	AGE		
	<40 % (95% C.I.)	≥40 % (95% C.I.)	TOTAL % (95% C.I.)
COUGH			
MONTANA	16 (10 - 24)	25 (14 - 37)	21 (15 - 28)
TEXAS	13 (5 - 27)	21 (7 - 42)	17 (9 - 28)
NORTH CAROLINA	28 (11 - 52)	24 (10 - 43)	26 (15 - 40)
POTASH	20 (16 - 24)	30 (26 - 34)	25 (21 - 29)
ABOVEGROUND COAL	16 (10 - 23)	35 (30 - 41)	25 (21 - 29)
UNDERGROUND COAL	18 (16 - 20)	45 (43 - 46)	30 (29 - 32)
PHLEGM			
MONTANA	21 (14 - 29)	18 (9 - 30)	19 (13 - 26)
TEXAS	14 (6 - 28)	21 (7 - 41)	16 (8 - 26)
NORTH CAROLINA	13 (2 - 35)	32 (16 - 51)	15 (6 - 29)
POTASH	25 (21 - 29)	34 (30 - 38)	29 (25 - 33)
ABOVEGROUND COAL	18 (13 - 25)	41 (35 - 47)	29 (25 - 33)
UNDERGROUND COAL	32 (31 - 35)	50 (46 - 53)	41 (39 - 41)

SUMMARY

COUGH: All talc populations <underground coal in ≥40 age group and overall. No difference among talc and other comparison populations.

PHLEGM: <40 - Underground coal had greater prevalence than all populations except North Carolina. No differences among the other populations.

≥40 - Talc populations no different from each other.
Montana and Texas <underground coal.
Montana <aboveground coal.

Total - All populations <underground coal but no different from each other.

TABLE 17

COMPARATIVE RATES (%) OF DYSPNEA AND PLEURAL THICKENING AMONG TALC WORKERS COMPARED TO POTASH MINERS, ABOVEGROUND AND UNDERGROUND COAL MINERS, STRATIFIED BY AGE AND INDIRECTLY ADJUSTED FOR SMOKING

	AGE		
	<40	≥40	TOTAL
	% (95% C.I.)	% (95% C.I.)	% (95% C.I.)
DYSPNEA			
MONTANA	3 (1 - 8)	7 (2 - 16)	5 (2 - 10)
TEXAS	4 (0 - 15)	15 (4 - 35)	9 (4 - 18)
NORTH CAROLINA	0 (0 - 16)	14 (4 - 31)	6 (1 - 17)
POTASH	5 (3 - 7)	12 (9 - 16)	8 (6 - 10)
ABOVEGROUND COAL	2 (1 - 7)	28 (23 - 34)	14 (11 - 17)
UNDERGROUND COAL	10 (9 - 11)	41 (40 - 42)	24 (23 - 25)
PLEURAL THICKENING			
MONTANA	2 (0 - 6)	11 (4 - 22)	6 (3 - 11)
TEXAS	3 (0 - 14)	32 (15 - 53)	17 (9 - 28)
NORTH CAROLINA	12 (2 - 34)	25 (11 - 44)	18 (9 - 31)
POTASH	0 (0 - 1)	3 (2 - 4)	2 (1 - 3)
ABOVEGROUND COAL	0 (0 - 3)	1 (0 - 3)	0.3 (0 - 1)
UNDERGROUND COAL	0.2 (0-0.3)	1 (.5 -1.5)	1 (.5 - 1.5)

SUMMARY

DYSPNEA: <40 - No difference among talc, potash, and aboveground coal populations. Montana less than underground coal.

≥40 - No difference among talc and potash populations, and all had less dyspnea than underground coal. Montana had less prevalence than aboveground coal.

Total - No difference among talc and potash populations. Underground coal had greater prevalence than all populations. Montana had less dyspnea than aboveground coal.

PLEURAL THICKENING: <40 - No difference among talc populations. North Carolina elevated compared to potash and underground coal.

≥40 and Total - No differences among talc populations. All populations had greater prevalence than nontalc populations.

TABLE 18

COMPARATIVE RATES OF OBSTRUCTION (FEV_1/FVC <.70) AMONG TALC WORKERS COMPARED TO OTHER MINING POPULATIONS.
STRATIFIED BY AGE AND INDIRECTLY ADJUSTED FOR SMOKING

	AGE		
	<40	≥40	TOTAL
	% (95% C.I.)	% (95% C.I.)	% (95% C.I.)
MONTANA	8 (4 - 15)	37 (25 - 50)	22 (16 - 29)
TEXAS	5 (5 - 17)	29 (15 - 51)	16 (9 - 27)
NORTH CAROLINA	0 (0 - 17)	36 (21 - 56)	17 (8 - 30)
POTASH MINERS	9 (6 - 12)	33 (29 - 37)	20 (17 - 23)
UNDERGROUND COAL	11 (10 - 12)	32 (31 - 33)	21 (20 - 22)
ABOVEGROUND COAL	8 (4 - 14)	31 (26 - 36)	19 (16 - 23)

SUMMARY: <40 - No differences
≥40 - No differences
Total - No differences

TABLE 19

SUMMARY OF PULMONARY FUNCTION REGRESSION MODELS AMONG TALC WORKERS (COMBINED AND BY REGION)
MODEL: $PFT = \alpha+\beta_1(sex) +\beta_2(mine) +\beta_3(age) +\beta_4(height) +\beta_5(pack\ years) +\beta_6(cumulative\ exposure)$

	SEX	MINE	AGE	HEIGHT	PACK YEARS	CUMULATIVE EXPOSURE (95% CONFIDENCE INTERVAL) UPPER	LOWER	r^2
FEV_1 (mL)	-572	N.S.	-30	+ 46	- 7	(- 3	+ 3)	.64
Montana	-608	N.S.	-30	+ 40	- 8	(- 27	+ 1)	.71
Texas	---	N.S.	-26	+ 33	(- 8)	(- 4	+ 3)	.48
North Carolina	(-212)	---	-25	+ 77	(- 9)	(- 31	+ 61)	.60
FVC (mL)	-865	N.S.	-19	+ 64	(- 3)	(- 5	+ 5)	.65
Montana	-1038	N.S.	-13	+ 53	(- 3)	- 35	- 6 *	.74
Texas	---	*	-21	+ 57	(- 8)	(- 5	+ 3)	.48
North Carolina	(-341)	---	(- 9)	+108	(- 6)	(- 84	+ 26)	.62
PEAK FLOW (mL/sec)	-1592	N.S.	-39	+ 80	-15	(- 12	+ 5)	.47
Montana	-1674	N.S.	-35	+ 74	(-13)	(- 57	+ 56)	.50
Texas	---	N.S.	(-25)	+ 63	(-17)	(- 13	+ 7)	.21
North Carolina	(-1298)	---	-54	+115	-25	(-179	+137)	.54
FEF_{50} (mL/sec)	N.S.	N.S.	-51	+ 27	-20	(- 4	+ 11)	.36
Montana	N.S.	N.S.	-57	+ 30	-19	(- 36	+ 32)	.40
Texas	---	*	-33	(- 5)	(-22)	(- 6	+ 12)	.22
North Carolina	N.S.	---	-60	(+ 36)	(-17)	(- 55	+ 94)	.44
FEF_{75} (mL/sec)	N.S.	N.S.	-37	+ 12	- 9	(- 4	+ 3)	.51
Montana	N.S.	N.S.	-42	(+ 14)	-10	(- 18	+ 14)	.55
Texas	---	N.S.	-26	(- 2)	(- 8)	(- 5	+ 3)	.40
North Carolina	N.S.	---	-40	+ 23)	(- 6)	(- 7	+ 52)	.63

N.S. or ( ) = not statistically significant.

If * or no ( ), then $p < .05$.

TABLE 20

MEAN ADJUSTED VALUES OF PULMONARY FUNCTION OF TALC WORKERS (n = 292)

MODEL: $PFT = \alpha+\beta_1(sex) +\beta_2(age) +\beta_3(height) +\beta_4(smoking\ status) +\beta_5(region) +\beta_6$ (cumulative exposure group).

	MEAN (S.E.)									
	FEV_1 (mL)		FVC (mL)		PEAK FLOW (mL/sec)		FEF_{50} (mL/sec)		FEF_{75} (mL/sec)	
SMOKING STATUS										
NONSMOKERS	3.72*	(.09)	4.59	(.10)	8.32	(.23)	4.63	(.19)	1.66	(.09)
EX-SMOKERS	3.59	(.09)	4.50	(.09)	8.62*	(.25)	4.57	(.21)	1.47	(.10)
SMOKERS	3.50	(.08)	4.48	(.08)	7.94	(.21)	4.20	(.18)	1.40	(.08)
REGION										
MONTANA	3.58	(.06)	4.65*	(.06)	8.51	(.16)	4.07*	(.13)	1.41	(.06)
TEXAS	3.52	(.10)	4.35	(.11)	8.45	(.27)	4.72	(.23)	1.51	(.10)
NORTH CAROLINA	3.71	(.11)	4.57	(.12)	7.92	(.29)	4.61	(.24)	1.61	(.11)
CUMULATIVE EXPOSURE GROUP										
LOW	3.10	(.08)	4.64*	(.08)	8.27	(.20)	4.23	(.17)	1.42	(.08)
MEDIUM	3.68	(.08)	4.59*	(.09)	8.28	(.23)	4.57	(.19)	1.59	(.09)
HIGH	3.53	(.09)	4.35	(.10)	8.33	(.25)	4.59	(.21)	1.53	(.10)

*Significant difference at .05 level.

TABLE 21

MEAN PERCENT PREDICTED PULMONARY FUNCTION OF MONTANA, TEXAS, NORTH CAROLINA TALC WORKERS COMPARED TO COMPARISON GROUPS, ADJUSTED FOR AGE, HEIGHT, AND SMOKING

	% PREDICTED PULMONARY FUNCTION = (observed/predicted) x 100				
	FEV_1 % (S.E.)	FVC % (S.E.)	PEAK FLOW % (S.E.)	FEF_{50} % (S.E.)	FEF_{75} % (S.E.)
COMPARISON POPULATIONS					
MALES ONLY (n = 251)					
POTASH	98.85 (1.01)	99.60 (.84)	93.19 (1.03)*	95.62 (2.10)*	88.23 (3.12)*
UNDERGROUND COAL	97.55 (1.01)*	95.09 (.80)*	100.19 (1.13)	95.62 (2.17)*	82.58 (2.75)*
ABOVEGROUND COAL	96.60 (1.01)*	96.62 (.83)*	112.43 (1.29)+	92.93 (2.00)*	80.76 (3.92)*

* = >2 S.E. less than 100

+ = >2 S.E. greater than 100

Discussion

Dr. Fraumeni (NCI): As this study progresses, will you be able to shed any light on the relationship of talc exposure and cancer.

Dr. Gamble (NIOSH): The population here is probably not too good for a mortality study at this point. The exposure histories, as we showed, are relatively short, even in North Carolina where it is only ten years. I think this population should be followed-up because of the pleural thickening and the concern for possible mesothelioma. But I do not know that we are going to have any answer for that for awhile.

I think the pleural thickening is of possible concern because of the relationship of pleural thickening in asbestos exposure. It is interesting that in Montana, where no asbestos fibers have been found, there was still an increase in pleural thickening. These populations should be followed.

National Cancer Institute

NIOSH

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OCCUPATIONAL CANCER STUDIES

MAY 6-8, 1980

SHERATON/POTOMAC, ROCKVILLE, MARYLAND

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