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Tuberculosis Comortality with Silicosis—United States, 1979–1991

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This article describes patterns of tuberculosis comortality with silicosis using national multiple-cause-of-death data. Mortality data are prepared annually by the National Center for Health Statistics, which records and codes all causes of death, both underlying and contributing, reported on the death certificate. We analyzed these data to evaluate tuberculosis mortality in decedents with silicosis from 1979 to 1991. The analysis was restricted to decedents 15 years and older at death and to black males and white males. Four groups were included in the analysis: all decedents with death certificate mention of silicosis; two comparison groups, one consisting of all decedents with asbestosis and another including all decedents with coal workers' pneumoconiosis (CWP); and a referent group composed of all decedents without silicosis, asbestosis, or CWP. Age- and race-specific proportions of deaths with tuberculosis were computed for all groups. Years of potential life lost (YPLL) to age 65 and to life expectancy were also computed. Among the 4261 decedents with silicosis from 1979 to 1991, tuberculosis mortality was 4.2 percent overall, ranging up to a maximum of 11 percent in the 35 to 44 year age group. Tuberculosis mortality in the referent group was 0.27 percent, reaching a maximum of 0.52 percent at 35 to 44 years. Among decedents with CWP, tuberculosis mortality was 0.77 percent overall; among decedents with asbestosis, tuberculosis mortality was 0.53 percent overall. In all age groups, proportions with tuberculosis among decedents with silicosis were at least four times those in both the comparison and reference groups. Among decedents with silicosis, tuberculosis mortality in black males was over twice that in white male decedents, 9.1 and 3.4 percent, respectively. Per capita YPLL to age 65 in decedents with both tuberculosis and silicosis was 1.3 times those in decedents with silicosis and no tuberculosis. These results from national mortality data are indicative of substantially higher tuberculosis mortality associated with silicosis. ALTHOUSE, R.B.; BANG, K.M.; CASTELLAN, R.M.: TUBERCULOSIS COMORTALITY WITH SILICOSIS—UNITED STATES, 1979–1991. APPL. OCCUP. ENVIRON. HYG. 10(12):1037–1041; 1995.

The association between silicosis and tuberculosis is well established.[1] Mortality studies in differing geographic settings and worker populations have provided the epidemiological evidence for this relationship. This article focuses on describing tuberculosis comortality with silicosis in the United States (i.e., patterns of tuberculosis mortality in decedents with silicosis by age, race, and state). For this purpose, we used national death certificate information, which lists all causes of death for every decedent in the United States. For comparative purposes, we also investigated tuberculosis comortality with two other dust-induced lung diseases, asbestosis and coal workers' pneumoconiosis (CWP). The advantage of multiple-cause-of-death compared with underlying-cause-of-death analysis is the unique opportunity to investigate the comortality of specific disease conditions.

Materials and Methods

Multiple-cause-of-death computer tapes have been prepared annually by the National Center for Health Statistics since 1968.[2] These records contain all causes of death noted on the death certificate for all U.S. decedents. Deaths with silicosis were defined as those with any mention of International Classification of Disease, 9th Revision (ICD-9)[3] code 502 ("pneumoconiosis due to other silica or silicates") on the death certificate. Similarly, deaths with asbestosis and deaths with CWP were defined, respectively, by ICD-9 code 501 ("asbestosis") and ICD-9 code 500 ("coal workers' pneumoconiosis"). Deaths with each of the above-mentioned conditions and with ICD-9 code 010-018 (tuberculosis) were selected for comortality analysis. Approximately 99 percent of deaths with tuberculosis fell under the ICD-9 rubric 011 ("pulmonary tuberculosis"). The two comparison groups were selected on the basis of having other mineral dust-induced pneumoconioses and on the assumption that these comparison groups can be expected to have been more similar than other possible comparison groups to decedents with silicosis in terms of socioeconomic status, a factor known to be associated with the occurrence of tuberculosis.

The period of interest was 1979 to 1991 in order to restrict it to years for which data were available and for which the ICD-9 coding system was used. [The ICD-8[4] coding system, in effect from 1968 to 1978, had two discrete codes for silicosis, ICD-8 code 515.1 ("silicosis") and ICD-8 code 010 ("silicotuberculosis").]

Several restrictions were applied to the initial records selected. Decedents less than 15 years of age were excluded due to the occupational nature of the pneumoconiotic disease conditions considered. Deaths with mention of more than one of the above conditions were excluded from the analysis; that is, decedents with silicosis and asbestosis or silicosis and CWP were eliminated. This restriction eliminated 143 decedents with silicosis and CWP, and 67 decedents with silicosis and asbestosis. Females were excluded, since 98 percent of decedents with silicosis were males. Other races than black and white were excluded, since they comprised only 0.3 percent of the total decedents with silicosis.

For each of the four groups mentioned above, age- and

TABLE 1. Number and Proportion of Decedents with Tuberculosis and Selected Respiratory Conditions and All Other Deaths by Race, U.S. Males Age 15 and Over, 1979–1991

	White		Black		Total	
Condition	Deaths	Percent with Tuberculosis	Deaths	Percent with Tuberculosis	Deaths	Percent with Tuberculosis
Silicosis	3615	3.4%	646	9.1%	4261	4.2%
Asbestosis	6844	0.4%	486	2.1%	7330	0.5%
CWP	29,854	0.9%	1024	1.4%	30,878	0.8%
All other deaths	11,880,862	0.2%	1,640,084	0.7%	13,520,946	0.2%

race-specific proportions with tuberculosis were computed for black males and for white males for the period 1979 to 1991. Age groups were divided into 10-year intervals: 15 to 24 years, 25 to 34, 35 to 44, and so on, up to 85+. Prevalence ratios were computed to compare the prevalence at death of tuberculosis among decedents with silicosis to the referent group (i.e., those with tuberculosis but not with silicosis, asbestosis, or CWP); decedents with CWP to the referent group; decedents with asbestosis to the referent group; and decedents with silicosis to the two comparison groups.[5] The ratio is computed by dividing the proportion of tuberculosis deaths in one group by the corresponding measure in the comparison group. A value close to 1 suggests no difference between the groups.

To further assess the premature mortality, per capita years of life lost (YPLL) to age 65 were computed[6] for decedents with and without tuberculosis for each dust-related condition. In this analysis the summation was divided by the number of deaths at ages less than 65 to produce years of life lost per capita. YPLL to age 65 is often used as a measure of loss of productive working years associated with death.

Results

In the period from 1979 to 1990, approximately 12,000,000 white males 15 years and over died in the United States. Of these, 22,649 (0.19%) had tuberculosis but not silicosis, asbestosis, or CWP mentioned as either the underlying or contributing cause of death on the death certificate. In comparably aged black males, approximately 1,600,000 deaths occurred over this same period. Tuberculosis was noted on 11,187 (0.68%) of the death certificates for this group. For selected conditions, Table 1 presents the numbers and percentages of decedents with death certificate mention of tuberculosis by race. Overall, decedents with tuberculosis represented 4.2 percent of those with silicosis, 0.78 percent of those with CWP, and 0.53 percent of those with asbestosis. Among decedents with no mention of silicosis, asbestosis, or CWP, 0.25 percent had tuberculosis mentioned on the death certificate. Proportions of tuberculosis deaths for black males were greater than proportions for white males in all four groups.

The overall prevalence ratio of tuberculosis among decedents with silicosis compared with tuberculosis in decedents without mention of silicosis was 21. Prevalence ratios comparing each of the control groups and referent group were 2.2 for decedents with asbestosis and 3.2 for decedents with CWP. Prevalence ratios of tuberculosis deaths in decedents with silicosis compared with the control groups were 7.9 (decedents with asbestosis) and 5.4 (decedents with CWP).

Figure 1 presents the age-specific proportions of deaths with tuberculosis in black males and white males 25 years and older. No deaths with tuberculosis and silicosis, asbestosis, or CWP were observed between 15 and 24 years. The age-specific distribution of deaths with tuberculosis among decedents without mention of asbestosis, CWP, or silicosis ranged from a maximum of 0.52 percent in the 35 to 44 year group to a minimum of 0.18 percent in ages 85 years and older. In decedents with asbestosis, the pattern of age-specific proportions of deaths with tuberculosis differed slightly from those of the referent group. No deaths with tuberculosis and asbestosis were reported below age 35. A maximum value of 1.1 percent occurred at 45 to 54 years, declined to a minimum of 0.35 percent in the 55 to 64 year age group, and then increased to 0.86 percent at ages 85 and over. The age-specific pattern of tuberculosis among decedents with CWP was roughly twice that of tuberculosis in all other deaths, demonstrating a fairly level pattern, with a minimum of 0.49 percent at 55 to 64 years. In comparison, proportions of deaths with tuberculosis occurring in decedents with silicosis were at least four times that of both the referent and each comparison group for all ages 35 years and older. No deaths with tuberculosis and silicosis were noted before age 35. The maximum value of 10.5

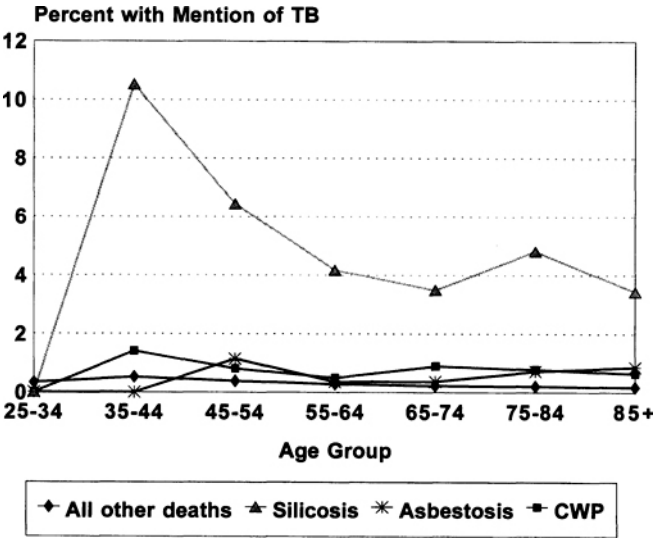

FIGURE 1. Age-specific proportions of deaths with tuberculosis for selected conditions and all other deaths, U.S. males age 15 and over, 1979–1991.

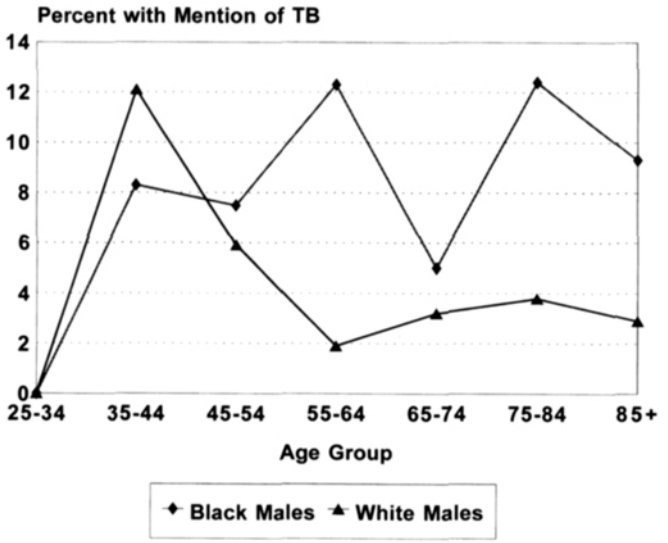

FIGURE 2. Age-specific proportions of silicosis deaths with tuberculosis by race, U.S. males age 15 and over, 1979–1991.

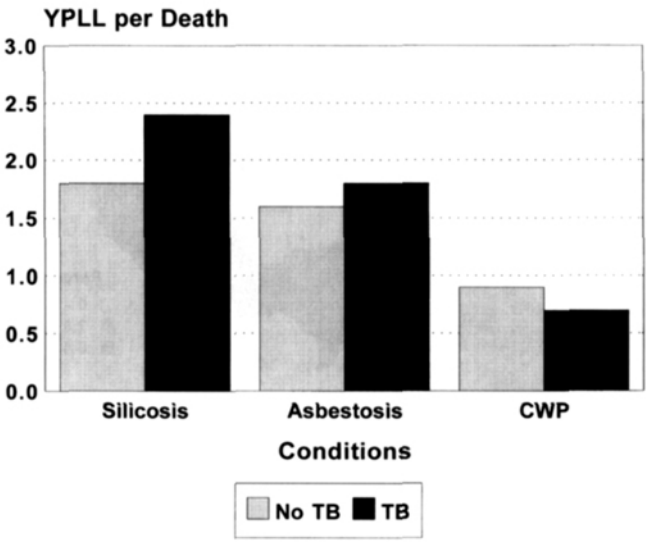

FIGURE 3. YPLL to age 65, U.S. males age 15 and over, 1979–1991.

percent occurred at age 35 to 44 and then declined to a minimum of 3.4 percent at age 85 and over.

Figure 2 presents age-specific proportions of silicosis deaths with tuberculosis by race. The smaller numbers of deaths in black males may account for the increased scatter observed. The main point of difference is that in all ages 45 years and over, age-specific proportions of deaths with tuberculosis were higher in black males than in white males. Overall, the proportion of silicosis decedents with tuberculosis among black males (9.1%) was more than twice that in white males (3.4%). Similarly, higher proportions of tuberculosis deaths in black males compared with white males were seen in decedents with CWP (1.4 and 0.87%, respectively), among decedents with asbestosis (2.1 and 0.42%, respectively), and in all other decedents (0.68 and 0.19%, respectively).

Figure 3 presents YPLL to age 65, per death, for decedents with and without tuberculosis in selected respiratory conditions. On average, each decedent with silicosis and tuberculosis lost 0.6 of a year of life more than those with silicosis and no tuberculosis. For decedents with asbestosis and tuberculosis the difference was 0.1 year. The relationship is reversed in decedents with CWP, where decedents without tuberculosis lost on average 0.1 year less of life than decedents with tuberculosis.

Among deaths with silicosis and tuberculosis, 1 percent had silicosis recorded as the underlying cause of death, 59 percent had tuberculosis recorded as the underlying cause, and 40 percent had another condition recorded as the underlying cause of death. For decedents with CWP and tuberculosis, CWP was coded as the underlying cause in 2 percent of deaths, tuberculosis was coded as the underlying cause in 72 percent of deaths, and other conditions were recorded as the underlying cause in 26 percent of deaths. Among decedents with asbestosis and tuberculosis, no deaths were reported with asbestosis as the underlying cause; tuberculosis was noted as the underlying cause in 49 percent of deaths; and other conditions were coded as the underlying cause in the remaining 51 percent of deaths. Comparably, among all other deaths with tuberculosis and none of the above mentioned dust conditions, tuberculosis was reported as the underlying cause in 45 percent of decedents.

Geographic patterns of the proportions of silicosis deaths with tuberculosis by race are shown in Figures 4 and 5. States with the highest proportions of silicosis deaths with tuberculosis among white males (and which had at least three such deaths) included West Virginia (10.4%, n = 7), Massachusetts (8.1%, n = 4), and Michigan (7.0%, n = 8). In contrast, the patterns observed in Figure 5 for black males showed a larger number of states, located predominantly in the eastern half of the United States, falling into the category with six or more percent of silicosis deaths having tuberculosis.

Discussion

The long-established relationship between tuberculosis and silicosis or exposure to silica has been supported by recent mortality studies of several types. For example, Steenland and Beaumont[7] observed a significantly elevated tuberculosis proportionate mortality ratio of 13.6 based on underlying causes of

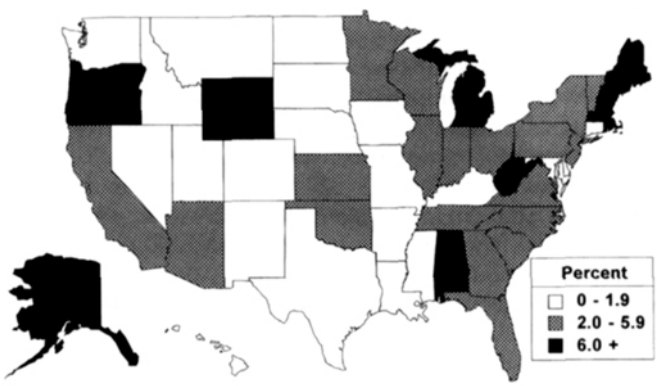

FIGURE 4. Proportions of silicosis deaths with tuberculosis by state, U.S. white males age 15 and over, 1979–1991.

FIGURE 5. Proportions of silicosis deaths with tuberculosis by state, U.S. black males age 15 and over, 1979–1991.

death in an analysis of union records of nearly 2000 silica-exposed granite cutters. In a cohort mortality study based on underlying causes of death on over 5000 granite workers identified from employer records, Costello and Graham[8] observed significantly elevated overall standardized mortality ratios (SMRs) for both silicosis (SMR 635.6) and tuberculosis (SMR 586.3). In a cohort mortality study of North Carolina males compensated for silicosis, Amandus *et al.*[9] reported significantly elevated tuberculosis SMRs of 30.7 among whites and 20.5 among blacks—observations that were also based only on underlying cause of death.

Our mortality analysis differs from the above approaches. Not only is it based on death data from the entire United States, but it takes advantage of available multiple-cause-of-death data to explore the association of tuberculosis with silicosis using both underlying and contributing causes of death. In demonstrating that tuberculosis is approximately 20 times more likely to be recorded as a cause of death among decedents with silicosis than among other decedents, our comortality findings strongly support the association of these two diseases and provide an overall national estimate of the strength of this association. Knowledge of the association between silicosis and tuberculosis in the medical community may influence physician diagnostic and death certificate recording practices, so it is possible that the observed strength of the association may be somewhat biased.

It is notable that among the comparison group of decedents with CWP, the prevalence of deaths with tuberculosis was 3.1 times that among the referent group, a ratio higher than that observed for the comparison group with asbestosis. Of these two comparison groups, CWP is clearly more similar to silicosis. In fact, coal mine dust contains variable amounts of silica, and one study reported that 12 percent of coal miners with CWP had pathological evidence of silicosis at postmortem examination,[10] which offers biological plausibility to the observed association of tuberculosis with CWP. A relationship between asbestosis and tuberculosis has not been suggested by previous studies, and the observed pattern of tuberculosis mortality among decedents with asbestosis, which very slightly exceeded that of the referent group, can probably be explained on the basis of socioeconomic factors. Perhaps a more likely explanation may be based on past silica exposure and clinically unrecognized silicosis among many workers, especially in construction jobs, who die with asbestosis.

Overall, the proportions of deaths with tuberculosis in decedents with silicosis were highest between the ages of 35 and 54, possibly influenced in part by the greater propensity of tuberculosis to be associated with acute and accelerated forms of silicosis.[11] A marked peak in the 35 to 54 year age interval is particularly evident among whites, whereas the very high proportions are generally sustained through the oldest age group among blacks. The limited available data preclude a full evaluation of this notable finding, although it clearly warrants further consideration. Among decedents with silicosis, the increased YPLL associated with tuberculosis relative to the comparison groups reflects the clinical observation that tuberculosis is more aggressive and more difficult to treat in individuals with silicosis,[11] as well as Bailey *et al.*'s[12] observation among sandblasters with silicosis that those with tuberculosis died at a lower average age.

Consistent with higher rates of tuberculosis among non-Hispanic blacks in the United States,[13] the comortality analysis revealed higher proportions of tuberculosis deaths in black males compared with white males in all four groups—silicosis, asbestosis, CWP, and referent. Prevalence ratios of tuberculosis at death among blacks relative to whites were higher for decedents in the referent group (0.68/0.19%, or 3.6) compared to decedents with silicosis (9.1/3.4%, or 2.7). The lower ratio observed in the silicosis decedents may result from control of confounding from differences in socioeconomic status in the referent group ratio. The differing geographic patterns, by race, of tuberculosis and silicosis comortality may reflect race-based differences in general socioeconomic factors, including access to and quality of medical care, by state.

In summary, the results of this comortality analysis of tuberculosis with silicosis are consistent with findings of published reports based on epidemiological studies of occupational groups. Despite the obvious limitations of death certificate data,[14] they serve to illustrate the utility of using national multiple-cause-of-death mortality data for descriptive assessment of comortality and for generating hypotheses regarding comortality.

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