

4. Chaves, A. D.: The problem of tuberculosis in selected populations. *In* Status of immunization of tuberculosis in 1971. Fogarty International Center Proceedings No. 14, DHEW Publication No. (NIH)72-68. National Institutes of Health, Bethesda, MD, 1972, pp. 19-41.
5. Reichman, L. B., Felton, C. P., and Edsall, J. R.: Drug dependence, a possible new risk factor for tuberculosis disease. *Arch Intern Med* 139:337-339 (1979).
6. Tuberculosis and acquired immunodeficiency syndrome—New York City. *MMWR* 36:785-790, 795, Dec. 11, 1987.
7. Human immunodeficiency virus infection in the United States: a review of current knowledge. *MMWR* 36(suppl S-6):1-48, Dec. 18, 1987.
8. Braun, M. M., et al.: Increasing incidence of tuberculosis in a prison inmate population. *JAMA* 261:393-397, Jan. 20, 1989.
9. Prevention and control of tuberculosis in correctional institutions: recommendations of the Advisory Committee for the Elimination of Tuberculosis. *MMWR* 38:313-320, May 12, 1989.
10. Snider, D. E., Jr., and Hutton, M. D.: Tuberculosis in correctional institutions (Editorial). *JAMA* 261:436-437, Jan. 20, 1989.
11. Centers for Disease Control: Guidelines for medical examination of Indochinese refugees in Southeast Asia. Department of Health and Human Services, Public Health Service, Atlanta, GA, 1987.
12. A strategic plan for the elimination of tuberculosis in the United States. *MMWR* 38 (suppl S-3):1-25, Apr. 21, 1989.

Tuberculosis Among American Indians of the Contiguous United States

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Synopsis

Paleopathologic findings provide strong evidence for the existence of tuberculosis in Andean populations of pre-Columbian America. Indirect evidence is available also to suggest its possible endemicity among some American Indian tribes who lived within the present-day contiguous United States

before the arrival of Europeans. The available data suggest that tuberculosis became a major health problem in some tribes with increased population density and cultural changes after increased contact with European civilization, paralleling the deterioration in living conditions after relocation of the tribes to reservations.

By 1900, tuberculosis had become one of the most serious health problems among North American Indians. Tuberculosis control was hampered by the lack of a specific treatment, and only the advent of specific chemotherapy in an ambulatory setting brought a breakthrough. Mortality, morbidity, and risk of infection have all sharply decreased over the past three decades. However, tuberculosis incidence rates among American Indians remain well above rates in the white population. An intensified effort to identify those with tuberculosis and those at risk of tuberculosis as well as to develop compliance-enhancing strategies with treatment regimens will be necessary to eliminate tuberculosis from Indian reservations.

THE ADVISORY COMMITTEE for the Elimination of Tuberculosis in the United States has called for a fresh assault on the tubercle bacillus (1). The Indian Health Service, represented on the Committee, has developed specific guidelines for the elimination of tuberculosis from Indian reservations (2). The purpose of this review is to add some background information on the history of tuberculosis among Indian tribes of the contiguous United States. The history of the disease among Alaskan

Natives has been described elsewhere in detail and was excluded from this review (3-5).

Epidemiology

Tuberculosis in pre-Columbian America. Tuberculosis in human beings has existed for at least 6,000 years (6). Acid-fast bacilli (AFB) have been documented in an Egyptian mummy with signs of spinal and pulmonary tuberculosis (7). Tuberculosis is

also mentioned in the Rig-Veda (ca 1500 BC) and in marriage codices in ancient India (8). However, the existence of tuberculosis in the Americas before the arrival of Europeans has been questioned (9). Many infectious diseases, such as smallpox, poliomyelitis, and measles, do not persist in small communities, because the causative organism spreads so efficiently that it rapidly kills or immunizes a high proportion of the population, and the virus cannot continue to propagate itself (10). In contrast, tuberculosis may remain endemic at low levels in small populations by virtue of the peculiarities of its natural history. The degree to which this pattern could exist without an extrinsic reservoir is, however, uncertain (11).

The findings in an autopsy of a mummified child who had lived about 700 AD in Peru are virtually pathognomonic of tuberculosis (12). Pleural and subpleural structures in the lungs, kidneys, and liver were compatible with miliary tubercles, and Ziehl-Neelsen staining revealed numerous AFB. The pericardium and heart contained structures that were histologically compatible with tubercles, and the lumbar vertebrae 1, 2, and 3 exhibited changes consistent with tuberculosis of the spine. Another report has provided additional evidence of AFB positive, cavitary pulmonary tuberculosis in Andean populations as early as 260 AD (13).

There is little room for doubt that tuberculosis existed among Andean populations in pre-Columbian times. The evidence for its pre-Columbian existence among Indian tribes who lived within the boundaries of the present-day contiguous United States, on the other hand, is much weaker.

Images of severely deformed hunchbacks as clay figurines and effigy water bottles have been recovered from prehistoric sites in Arkansas, Tennessee, Mississippi, and Missouri (14). It is believed that these items depict persons afflicted with tuberculosis of the spine (8,14). Pictographs recovered in the Southwest show hunchbacked figures lying down playing the flute (14). Skeletal remains recovered from sites in Tennessee and New York showed evidence compatible with tuberculosis of the spine (15).

Data from skeletons in mortuary sites in the lower Illinois River valley region were compiled for periods ranging from the Middle Woodland (150 BC to 400 AD) through the Mississippian Period, which began about 1050 AD (11). The Middle Woodland groups lived as hunters and gatherers, but they were also cultivators, living in base camps within the major river valleys. Population density was low, and no indication for extensive popula-

tion movement or migration was evident. Contacts with other tribes thus may have been few. No evidence of tuberculosis has been found for this period. A calcified piece of pleura which may represent tuberculosis was found in remains from the early Late Woodland Period (400 AD-800 AD).

By Late Woodland (850 AD-1050 AD), a major change had taken place. The introduction of maize cultivation influenced settlement patterns. Although hunting and gathering remained important subsistence strategies, no evidence for extensive trade with other groups or of migration could be demonstrated. Skeletal remains from this period show signs of changes which could be attributable to either tuberculosis or blastomycosis. The lifestyle in the Mississippian Period (after 1050 AD) made tuberculosis more likely, because there were larger population aggregations. Changes suggestive of tuberculosis were discovered in young adults. Traces of skeletal abnormalities compatible with tuberculosis seemed to appear with increased population density and increased probability of interregional transmission of the tubercle bacillus. However, blastomycosis remains an important differential diagnosis for the osseous pathologies that have been reported. Buikstra and Cook hypothesize that a new disease, probably tuberculosis, was introduced into west-central Illinois during the last millennium (11).

Further evidence for the presence of tuberculosis comes from skeletal remains on the east bank of the Little Miami River in Hamilton County, OH (16). Six skeletons, carbon dated AD 1125 to 1425 with characteristics compatible with tuberculosis of the spine, were recovered.

Tuberculosis after contact with the European civilization. From the first contacts between American Indians and European immigrants until the end of the 19th century, the dramatic cultural changes and the deteriorating living conditions that occurred after 18th and 19th century relocations were paralleled by a worsening of the tuberculosis situation among various tribes. By the end of the 19th century, tuberculosis had become a serious health problem.

In 1887, Matthews reported proportions of deaths from tuberculosis among reservation Indians in 13 different States (17). These proportions ranged from 45 per 1,000 deaths in Nevada to 625 per 1,000 deaths in New York. He noticed that in States east of the Mississippi, that is, where Indians had the longest contact with Europeans, the proportion of tuberculosis deaths among all deaths

were highest. He noted increases on certain reservations. For Cheyenne River, SD, he found, for example:

<i>Calendar year</i>	<i>TB deaths per 1,000 deaths</i>
1878.....	407
1879.....	550
1880.....	425
1881.....	417
1882.....	?
1883.....	561
1884.....	639
1885.....	649

Geare reported on tuberculosis among the Southern Ute and among the Apaches in Arizona and New Mexico in the beginning of this century (18). On one reservation among a population of about 3,000, more than 36 percent of 255 deaths occurring between 1901 and 1903 were due to different forms of tuberculosis. He found that tuberculosis also was common among Zuni and Papago Indians.

Aronson (19) followed for an average of 10 years 975 Indian children who were tuberculin negative when first tested in 1935-37 (children from Alaska were excluded here). At the end of the observation period, 313 (32.1 percent) were tuberculin positive, for an average annual risk of infection of 3.8 percent.

In the early 1930s, the annual incidence of tuberculosis in an Apache community of 2,700, living on the San Carlos Reservation, was 1 percent (58 cases in 2 years) (20). By the seventh grade, 100 percent of the children were tuberculin positive.

From 1870 to 1936 the Navajo population increased from 8,000 to 50,000 (21). A study of 4,826 admissions to Sage Memorial Hospital in Ganado, AZ, in the early 1930s ranked tuberculosis fourth after influenza, trachoma, and tonsillitis; it accounted for 3.0 percent of all admissions (21). By the end of the 1950s the Navajo numbered 85,000. In 1950, tuberculosis was one of the leading causes of death on the Navajo Reservation (22). There was only one hospital with 100 beds for the entire tribe, and case finding programs had to be abandoned because patients could not be cared for. Estimates of active tuberculosis ranged from 2 to 3 percent, and 50 to 60 percent of 6- to 10-year-old children were tuberculin positive, for an average annual risk of infection of about 9 percent.

In 1952, the year that isoniazid was discovered, a government program contracted with off-reservation sanatoriums to care for patients with infectious pulmonary tuberculosis (22). Arrangements

were made with Cornell University to provide staff for the hospital at Fort Defiance, AZ. With the widespread use of effective antituberculosis drugs and appropriate staffing, tuberculosis mortality had dropped 40 percent by 1957. By 1959, the prevalence of tuberculous infection among the 6- to 10-year-olds had fallen to 20 percent, for an annual risk of infection of about 2.6 percent (22). In 1972, a tuberculin skin test survey among Navajos in the Red Rock area showed a prevalence of 3.7 percent tuberculin reactors among children ages 5 to 9 years, an annual risk of infection of about 0.5 percent (23). This level represents an estimated average decline in the annual risk of infection of 12 percent per year from 1959 to 1972.

Between 1955 and 1981, the tuberculosis incidence rate among American Indians (excluding Alaskan Natives) had dropped from 563.2 per 100,000 to 50.9 per 100,000 Indian population, an average annual decline of 8.8 percent ("Tuberculosis Morbidity," unpublished table from the Vital Events Branch, OPS, DRC, Indian Health Service, Nov. 4, 1982). In 1985, 397 cases of tuberculosis among American Indians and Alaskan Natives were reported, for a case rate of 25.0 per 100,000 population, still 4.4 times higher than the rate of 5.7 per 100,000 among whites (24). Tuberculosis case rates among American Indians in many reservation States were considerably higher than the rates among other races in these States.

Treatment of Tuberculosis

The prechemotherapy era. Disability, particularly of young people, attributable to chronic diseases, was believed by most Indian tribes to be incited by some adverse natural or supernatural power. The help of medicine women and men who were believed to have supernatural powers was sought to counteract the powers that caused the disease (18, 19). The Navajos called tuberculosis a "fading away of the heart." They thought that it was caused by improperly performed wind chants or contact with an object, such as a tree struck by lightning (22). It was not considered contagious.

In 1896, James R. Walker was assigned as agency physician to the Pine Ridge Reservation, SD (25). He noted that the prevailing disease among the Oglala Sioux was tuberculosis and "... that the greatest difficulty in the management of the disease on an Indian Reservation is the lack of control of cases, arising principally from the antagonism of the Indian medicine men." He realized the pivotal role of medicine men in the society and

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sought their friendship to learn about concepts and beliefs concerning the etiology and traditional methods of treating tuberculosis. He introduced then current measures of control on the reservation, such as the safe disposal of waste and sputum, and general sanitary measures. From 1897 to 1903, the annual incidence of tuberculosis declined by 49 percent, and the mortality from tuberculosis by 44 percent. He also proposed the construction of a sanitary camp on the reservation to remove the infectious from the general community, but guaranteeing that patients could stay close to their kin and cultural environment (26). Unfortunately, his plans bore no fruits (25).

The chemotherapy era. Mass chemotherapy became a historically unprecedented weapon in tuberculosis control in the early fifties (27). A study comparing treatment of tuberculosis in sanatoriums with ambulatory chemotherapy in Madras, south India, demonstrated the efficacy and feasibility of ambulatory chemotherapy (28). In the United States, the change from sanatorium treatment to ambulatory chemotherapy was gradual over more than two decades. The first step was a shift from sanatorium toward general hospital treatment. The use of general hospitals in the treatment of tuberculosis was endorsed by a committee of the American College of Chest Physicians in 1972 (29). In 1971, 28 States reported that general hospitals were being used for the care of tuberculosis patients (30). In 1973, only 17 States reported using specialized tuberculosis hospitals exclusively (31). In 1981, 15 of these 17 States reported some use of general hospitals (32). Over the same period (1972 to 1981), treatment of tuberculosis also gradually shifted from hospital to ambulatory care sites (33). The feasibility and apparent success of ambulatory

chemotherapy in Alaska (34) may have accelerated the introduction of ambulatory chemotherapy by the Indian Health Service on reservations in the contiguous United States. Between 1969 and 1972 an ambulatory therapy program with drugs given twice weekly was initiated among White Mountain Apache Indians (35). Patients were hospitalized for 5 to 56 weeks and then allowed to complete their 2-year course of treatment at home.

Tuberculosis control in the 1980s on Indian reservations. For the majority of patients, ambulatory, short-course chemotherapy has become the treatment of choice on Indian reservations, as elsewhere in the United States (2, 36). As in other populations, noncompliance remains the most serious problem. In addition to the difficulty all patients have in comprehending the need to prolong chemotherapy beyond the achievement of physical well-being, mistrust of "white man's" medicine among American Indians remains to some extent and stems from traditional beliefs about disease etiology and treatment of disease ("Tuberculosis on the Pine Ridge Reservation. Directed Study in Nursing," by L. Means, of the Aberdeen Area Indian Health Service, written personal communication, May 1986). Because treating a tuberculosis patient is not synonymous with administration of chemotherapy, the patients' beliefs and cultural background must also be considered in the design of treatment programs (37).

Outlook

With the decline of the risk of infection, tuberculosis among American Indians increasingly emanates from the pool of persons with latent tuberculous infection, acquired years earlier. The identification of groups at high risk of tuberculosis among those infected becomes increasingly important. The elimination of tuberculosis among American Indians will require the integration of traditional medicine into treatment programs in ensuring the patient's compliance; the use of health care workers from within the tribe; a continued high suspicion of tuberculosis; an intensified use of existing tools of control, particularly of preventive therapy for those at risk of developing active tuberculosis; and the use of directly observed short-course therapy for those patients who have difficulties in complying with self-administered therapy (2). The elimination of tuberculosis, a disease that is considered curable and preventable by the medical community, poses a challenge to

health care providers (1,38). A concerted effort and the cooperation of all concerned with the health of Indian people can turn the dream of eliminating tuberculosis from Indian reservations into reality.

References.....

1. Centers for Disease Control: A strategic plan for the elimination of tuberculosis in the United States. *MMWR* 38(suppl no. S-3): 1-25, Apr. 21, 1989.
2. Welty, T. K., et al.: Control of tuberculosis among American Indians and Alaskan Natives. *The IHS Primary Care Provider* 14: 53-54 (1989).
3. Comstock, G. W., and Philip, R. N.: Decline of the tuberculosis epidemic in Alaska. *Public Health Rep* 76: 19-24 (1961).
4. Johnson, M. W.: Results of 20 years of tuberculosis control in Alaska. *Health Serv Rep* 88: 247-254 (1973).
5. Grzybowski, S., Styblo, K., and Dorken, E.: Tuberculosis in Eskimos. *Tubercle* 57(suppl): S1-S58 (1976).
6. Formicola, V., Milanese, Q., and Scarsini, C.: Evidence of spinal tuberculosis at the beginning of the fourth millennium BC from Arene Candide Cave (Liguria, Italy). *Am J Phys Anthropol* 72: 1-6 (1987).
7. Zimmerman, M. R.: Pulmonary and osseous tuberculosis in an Egyptian mummy. *Bull NY Acad Med* 55: 604-608 (1979).
8. Webb, G. B.: *Tuberculosis*. Paul B. Hoeber Inc., New York, 1945.
9. Morse D.: Prehistoric tuberculosis in America. *Am Rev Respir Dis* 83: 489-504 (1961).
10. Black, F. L.: Infectious diseases in primitive societies. *Science* 187: 515-518, Feb. 14, 1975.
11. Buikstra, J. E., and Cook, D. C.: Pre-Columbian tuberculosis in West-Central Illinois: Prehistoric disease in biocultural perspective. In *Prehistoric tuberculosis in the Americas*, J. E. Buikstra, editor. Northwestern University Archeological Program, Evanston, IL, 1981, pp 115-139.
12. Allison, M. J., Mendoza, D., and Pezzia, A.: Documentation of a case of tuberculosis in pre-Columbian America. *Am Rev Respir Dis* 107: 985-991 (1973).
13. Allison, M. J., et al.: Tuberculosis in pre-Columbian Andean populations. In *Prehistoric tuberculosis in the Americas*, J. E. Buikstra, editor. Northwestern University Archeological Program, Evanston, IL, 1981, pp 49-61.
14. El-Najjar, M. Y.: Human treponematosi and tuberculosis: Evidence from the new world. *Am J Phys Anthropol* 51: 599-618 (1979).
15. Ritchie, W. A.: Pathological evidence suggesting pre-Columbian tuberculosis in New York State. *Am J Phys Anthropol* 10: 305-317 (1952).
16. Widmer, L., and Perzigian, A. J.: The ecology and etiology of skeletal lesions in late prehistoric populations from Eastern North America. In *Prehistoric tuberculosis in the Americas*, J. E. Buikstra, editor. Northwestern University Archeological Program, Evanston, IL, 1981, pp 99-113.
17. Matthews, W.: Consumption among the Indians. *NY Med J* 45: 1-3 (1887).
18. Geare, R. I.: Some diseases prevalent among Indians of the Southwest and their treatment. *Medical World* 33: 305-310 (1915).
19. Aronson, J. D.: The fluctuation of the tuberculin reaction in different geographic areas and its relationship to resis-

20. Hancock, J. G.: Diseases among the Indians. *Southwestern Medicine* 17: 126-129 (1933).
21. Salisbury, C. G.: Disease incidence among the Navajos. *Southwestern Medicine* 21: 230-233 (1937).
22. Dueschle, K.: Tuberculosis among the Navajo. *Am Rev Respir Dis* 80: 200-206 (1959).
23. Tempest, P., and Pesanti, E., Jr.: A community-wide tuberculosis case finding program on the Navajo reservation. *Am Rev Respir Dis* 110: 760-764 (1974).
24. Centers for Disease Control: Tuberculosis among American Indians and Alaskan Natives—United States, 1985. *MMWR* 36: 493-495, Aug. 7, 1987.
25. DeMallie, R. J., and Jahner, E. A.: Part I, James R. Walker: His life and work, In *James R. Walker: Lakota belief and ritual*, edited by R. J. DeMallie and E. A. Jahner. University of Nebraska Press, Lincoln and London, 1980, pp 1-61.
26. Walker, J. R.: Tuberculosis among the Oglala Sioux Indians. *Am J Med Sci* 132: 600-605 (1906).
27. Comroe, J. H., Jr.: Pay dirt. The story of streptomycin. Pt II. Feldman and Hinshaw; Lehman. *Am Rev Respir Dis* 117: 957-968 (1978).
28. Tuberculosis Chemotherapy Centre, Madras: A concurrent comparison of home and sanatorium treatment of pulmonary tuberculosis in South India. *Bull WHO* 21: 51-144 (1959).
29. American College of Chest Physicians, Report of the Committee on Tuberculosis: Utilization of general hospitals in the treatment of tuberculosis. *Chest* 61: 405 (1972).
30. Dandoy, S., and Elman, S. B.: Current status of general hospital use for tuberculous patients in the United States. *Am Rev Respir Dis* 106: 580-586 (1972).
31. Dandoy, S., and Wiggins, K.: Current status of general hospital use for patients with tuberculosis in the United States: an update. *Am Rev Respir Dis* 110: 442-445 (1974).
32. Dandoy S.: Current status of general hospital use for patients with tuberculosis in the United States. Eight-year update. *Am Rev Respir Dis* 126: 270-273 (1982).
33. Bates, J. H.: Ambulatory treatment of tuberculosis—an idea whose time is come [Editorial]. *Am Rev Respir Dis* 109: 317-318 (1974).
34. Porter, M. E., and Comstock, G. W.: Ambulatory chemotherapy in Alaska. *Public Health Rep* 77: 1021-1032 (1962).
35. Mikkelson, M. K., et al.: Ambulatory tuberculosis chemotherapy on an Indian reservation. *Chest* 64: 570-573 (1973).
36. American Thoracic Society/Centers for Disease Control: Treatment of tuberculosis and tuberculosis infection in adults and children. *Am Rev Respir Dis* 134: 355-363 (1986).
37. Hershfield, E.: Discussion session. In *Compliance, resistance and cost: major considerations in tuberculosis control*. *Tubercle* 68(suppl): 47-51 (1987).
38. American Thoracic Society/Centers for Disease Control/National Institutes of Health/Pittsfield Antituberculosis Association: Future research in tuberculosis: prospects and priorities for elimination. *Am Rev Respir Dis* 134: 401-420 (1986).