

Active Tuberculosis among U.S. Army Personnel, 1980 to 1996

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Objective: To describe hospitalization rates for active tuberculosis among U.S. Army personnel. **Methods:** All hospitalizations for tuberculosis among Army active duty personnel from January 1, 1980, to December 31, 1996, were identified from an inpatient database. Incidence rates and trend analyses are presented for age, race, sex, and hospital location. **Results:** A total of 926 cases of active tuberculosis required hospitalization. Hospitalization rates declined from 15.3 cases/100,000 (1980) to 5.1 cases/100,000 (1996). Significant declines in hospitalization rates occurred for white and black males but not for females. Tuberculosis rates were 3.5 times lower among soldiers compared with the general population for individuals 25 to 44 years of age. **Conclusion:** Because of medical, purified protein derivative, and human immunodeficiency virus screening, military populations represent a low-risk population for active tuberculosis. The Army's overall hospitalization rate for tuberculosis declined steadily but remained relatively high among minorities and females. Additional studies should address specific risk factors related to race and gender among healthy populations with adequate health care.

Introduction

Tuberculosis continues to be a global public health problem despite the recent success in reducing incident cases within the United States. During 1997, a total of 19,855 cases (7.4/100,000) were reported to the Centers for Disease Control and Prevention (CDC), representing a 26% decrease from case numbers reported in 1992.¹ In contrast, the worldwide incidence of tuberculosis is increasing. An estimated 8 million incident cases and 3 million tuberculosis deaths are reported annually worldwide.² The magnitude of the problem and the increasing number of cases prompted the World Health Organization to declare tuberculosis a global public health emergency in 1993, the only disease given that dubious distinction to date.

Today, the increased number of U.S. military operations targeted to alleviate the effects of political instability, civil strife, and natural disasters in countries endemic for tuberculosis has increased the exposure risk for U.S. soldiers. For example, in November 1991, after a military coup in Haiti, thousands of refugees were taken to Guantanamo Bay, Cuba. Of the 7,700 refugees who received chest radiography, approximately 5% had abnormalities suggestive of pulmonary tuberculosis; 30% of these had evidence of active disease.³ Up to 3.7% of the deployed

U.S. security forces became infected with tuberculosis as a result of their contact with refugees at Guantanamo Bay (Dr. Mark Kortepeter, personal communication, September 1998).

The Army maintains a comprehensive and aggressive tuberculosis control program. Screening for tuberculosis infection by the Mantoux method, using intermediate-strength purified protein derivative (PPD), is mandated upon entering the service, before and after overseas deployments, and at least annually for those in health care occupations.⁴ Furthermore, in 1986, the military instituted mandatory biennial human immunodeficiency virus (HIV) screening. Applicants who test positive for HIV are barred from military service. Those active duty members testing HIV-positive are prohibited from all overseas deployments.⁵

Within the military, soldiers with active tuberculosis are routinely hospitalized to prevent exposing others and to ensure the initiation of appropriate treatment. This fact and the centralized inpatient and personnel databases containing demographic and geographic location information make the use of existing databases practical for the surveillance of active tuberculosis within military populations. The objective of this study was to calculate hospitalization rates for active tuberculosis among U.S. Army personnel, assess long-term trends, and identify risk factors that may be helpful in improving the Army's tuberculosis control program.

Methods

U.S. Army active duty personnel discharged from any hospital (military or civilian) with a diagnosis of active tuberculosis from January 1, 1980, to December 31, 1996, are included in this study. The majority of cases (898) were obtained from the Patient Administration Systems and Biostatistical Activity database (Fort Sam Houston, Texas). The Naval Health Research Center (San Diego, California) and the Office of Prevention and Health Services Assessment (Brooks Air Force Base, Texas) provided additional data on Army personnel discharged from Navy (23 cases) and Air Force (15 cases) hospitals.

Cases were identified using the following International Classification of Diseases, Ninth Revision, Clinical Modification codes: 010 (primary tuberculosis), 011 (pulmonary tuberculosis), 012 (other respiratory tuberculosis), 013 (tuberculosis of the meninges and central nervous system), 014 (tuberculosis of the intestines, peritoneum, and mesenteric glands), 015 (tuberculosis of the bone and joints), 016 (tuberculosis of the genitourinary system), 017 (tuberculosis of other organs), and 018 (military tuberculosis).⁶

Only the first hospitalization for each person with tuberculosis was included in the study. A hierarchical system was used to categorize each patient when multiple tuberculosis diagnoses

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existed. Of the 17 patients with multiple tuberculosis discharge diagnoses, 13 were classified as having pulmonary tuberculosis, 3 were classified as having other respiratory tuberculosis, and 1 was classified as having military tuberculosis.

Denominator data for gender, race, rank, and age were obtained from the Defense Manpower Data Center (Seaside, California). Geographic location (by country) of active duty personnel was obtained from the Statistical Information Analysis Division of the Directorate for Information Operations and Reports (Washington, DC). The Army Medical Surveillance Activity provided person-year denominators for age- and gender-specific rate calculations from 1990 to 1996. In addition, the Army Medical Surveillance Activity provided information on HIV status, health care occupational status, and previous deployments without individual identifiers. Linear trends for race and gender hospitalization rates were assessed using a χ^2 statistic.⁷ Logistic regression was performed to control for confounding variables.

Results

For the 17 years under study (1980–1996), a total of 936 U.S. Army active duty members were identified with active tuberculosis. Approximately 80% involved either pulmonary (70.7%) or other respiratory (8.8%) cases (Table I). The hospitalization rate for tuberculosis among the U.S. Army active duty population declined from a high of 15.3/100,000 population in 1980 to 5.1/100,000 population in 1996 (Fig. 1). Blacks and other minorities (Asian/Pacific Islanders, American Indians, and Alaskan Natives) were overrepresented among the cases. Blacks accounted for 46.0% (431) and other minorities accounted for 11.3% (106) of the 936 cases ($p < 0.01$), although only 29.0% and 4.5% of U.S. Army personnel in 1990 were identified as black or other minorities, respectively. Coding for Hispanic background was absent before 1986. Depending on other available ethnicity information, Hispanics of black or white origin were included as blacks or whites, respectively ($N = 24$). Another 7 Hispanic personnel with active tuberculosis could not be categorized as of black or white origin and were excluded from the incidence rate by race calculations. Rates among white, black, and other races declined significantly during this 17-year period (χ^2 for trend, $p = 0.001$ for total, white, black, and other races). From 1980 to 1996, rates among blacks declined from 24.5/

100,000 to 6.9/100,000 population. Other minorities also experienced a steady decline in tuberculosis from 50.3/100,000 in 1980 to 16.7/100,000 in 1996.

Analyses of hospitalization admission rates by gender and race are presented by 2-year averages starting in 1981 because of the relatively small number of female cases (Fig. 2). Other minorities were excluded because of insufficient numbers of cases. Although both black and white men experienced a significant decline in tuberculosis during the study period (χ^2 for trend, $p = 0.001$), significant declines were not found among black or white females. Since 1991, female rates actually increased relative to the late 1980s and now exceed male rates among both whites and blacks in 1995/1996 (white females, 4.8/100,000 versus white males, 3.5/100,000; black females, 11.9/100,000 versus black males, 7.7/100,000).

Tuberculosis rates were calculated for officer and enlisted personnel. Although the rate disparities between officers and enlisted personnel have narrowed, enlisted rates were found to be two to four times higher than officer rates. From 1980 to 1996, enlisted rates declined from 16.9/100,000 to 6.0/100,000 population, whereas officer rates declined from 4.1/100,000 to 1.3/100,000. Black officers were two times more likely to be hospitalized for tuberculosis than white officers.

Affected personnel ranged in age from 17 to 54 years. The average age was 32.5 years for males and 28.7 years for females. As expected, the risk of tuberculosis increased with age, from 5.2/100,000 for those younger than 20 years to 15.8/100,000 for those older than 40 years. Gender- and age-specific denominator data were available only from 1990 to 1996; therefore, incidence density rates by gender and age were calculated only for this period. Tuberculosis hospitalization rates for females exceeded male rates across all age groups and reached statistical significance for individuals aged 20 to 34 years ($p < 0.01$) (Fig. 3). Female patients were 3.2 times more likely than male patients to work in health care-related fields (95% confidence interval, 1.70–6.04).

The majority of the cases occurred among 25- to 44-year-old personnel (59.8%). To compare the rates in the Army with those in the general U.S. population, an indirect adjustment using U.S. rates of active tuberculosis for white and black non-Hispanic males and females aged 25 to 44 years was performed (Table II). The actual Army rate among individuals 25 to 44 years

TABLE I
FIRST HOSPITALIZATION DISCHARGE DIAGNOSES FOR TUBERCULOSIS AMONG U.S. ARMY ACTIVE DUTY PERSONNEL
BY ICD-9-CM CODE, 1980 TO 1996

Tuberculosis Classification	ICD-9-CM Code	Case (No.)	Percent
Primary tuberculosis	010	35	3.7
Pulmonary tuberculosis	011	662	70.7
Other respiratory tuberculosis	012	82	8.8
Tuberculosis of the meninges and central nervous system	013	11	1.2
Tuberculosis of the gastrointestinal tract	014	11	1.2
Tuberculosis of the bones and joints	015	44	4.7
Tuberculosis of the genitourinary system	016	20	2.1
Tuberculosis of other organs	017	62	6.6
Military tuberculosis	018	9	1.0
Total		936	

ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification.

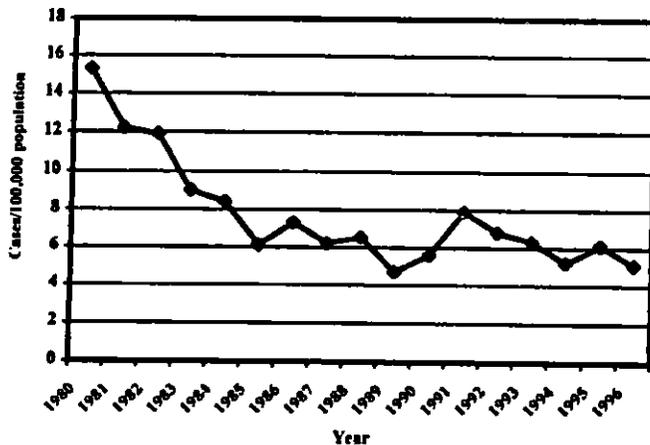


Fig. 1. Tuberculosis hospitalization rates, U.S. Army active duty personnel, 1980 to 1996.

old determined to be either black or white non-Hispanic was 5.1/100,000 in 1995/1996; the U.S. rate was 6.2/100,000. When gender- and race-specific U.S. rates were applied to the Army population, the adjusted rate was 14.2/100,000.

Of the 930 patients with hospital location data, 606 (65%) were hospitalized in the United States, 204 (22%) were hospitalized in Germany, and 100 (11%) were hospitalized in South Korea. Rates for the U.S. Army hospital located in Korea declined from a high of 38.8/100,000 in 1981 to 10.2/100,000 in 1996 but remained consistently higher than those found in U.S. Army hospitals in the United States and Germany.

Deployment status data have been kept since the Persian Gulf War began in 1990. Comparison of active tuberculosis cases occurring since this time revealed that only 28.7% of affected personnel had ever been deployed to a developing country before their diagnosis.

Although comorbidity could not be addressed individually in this study because of confidentiality concerns, 21 (2.2%) of the 936 tuberculosis patients were infected with HIV. Of these patients, 20 were diagnosed with pulmonary tuberculosis (2 with primary pulmonary tuberculosis), and 1 was diagnosed with military tuberculosis.

Logistic regression demonstrated that female gender, non-white race, and being older than 40 years were independent risk factors for being hospitalized with active tuberculosis even after

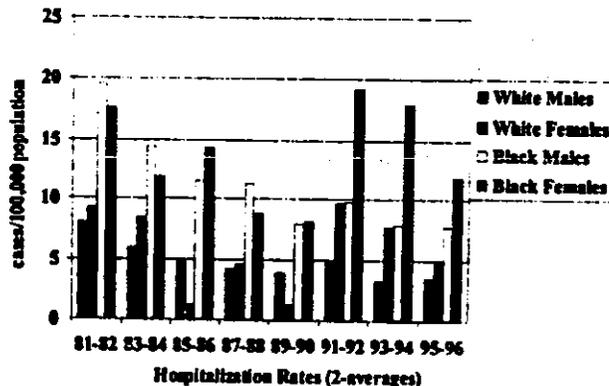


Fig. 2. Tuberculosis hospitalization rates by race and gender, U.S. Army active duty personnel, 1981 to 1996.

Active Tuberculosis in U.S. Army Personnel

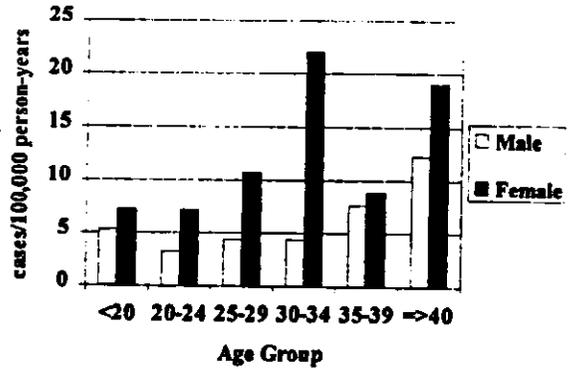


Fig. 3. Tuberculosis hospitalization rates by gender and age, U.S. Army active duty personnel, 1990 to 1996.

controlling for year of hospitalization. Working in a medical field, deployment, and HIV status could not be considered in the model because personal identifiers were not available to link these data.

Discussion

General Trends

Mirroring the trend in the general U.S. population, tuberculosis hospitalization rates for U.S. Army active duty personnel declined from 15.3/100,000 in 1980 to 5.1/100,000 in 1996. The total U.S. tuberculosis rate reported by the CDC decreased from 12.3/100,000 to 8.0/100,000 during this same period.⁸ When gender- and race-specific U.S. rates for 25- to 44-year-old individuals were applied to the Army population, the adjusted rate was far greater than the actual Army rate of 5.1/100,000, demonstrating the impact of lower tuberculosis rates experienced in the Army. The lower rates among black men aged 25 to 44 years in the Army (7.7/100,000) versus the U.S. population (41.4/100,000) account for most of this difference.

A limitation of the study is that cases of active tuberculosis were not confirmed by record review. Although the case finding may be imprecise, general trends of tuberculosis detection and differences by demographic characteristics should remain valid.

Several unique factors account for the U.S. Army's lower tuberculosis rates compared with the rates in the general U.S. population. Medical screening of soldiers before enlistment, biennial HIV testing, PPD screening of all high-risk personnel, and immediate hospitalization of patients with active tuberculosis are a few salient factors. Other military branches have also experienced a decline in tuberculosis hospitalizations. A similar study conducted among U.S. Navy enlisted personnel reported that tuberculosis hospitalization rates declined from 8.7/100,000 person-years in 1980 to 2.2/100,000 person-years in 1994.⁹ In comparison, our study found the Army's enlisted rate was 5.7/100,000 population (5.6/100,000 person-years, data not shown) in 1994, more than twice that found among Navy enlisted personnel. According to the Defense Manpower Data Center, the 1994 enlisted workforce profiles were similar among these two services for gender, age, and percentage of service members in health care occupations. However, in 1994, blacks accounted for only 18% of the U.S. Navy but made up 30% of the U.S. Army enlisted workforce.¹⁰ The higher tuber-

TABLE II
INDIRECTLY STANDARDIZED ACTIVE TUBERCULOSIS RATE FOR WHITE AND BLACK NON-HISPANICS AGE 25 TO 44 YEARS IN THE U.S. ARMY USING 1996 U.S. TUBERCULOSIS RATES

Race/Gender ^a	1995/1996 Army Rate/100,000	1996 U.S. Rate/100,000	1996 Army Population	Expected No. of Army Cases with U.S. Rates	Indirectly Adjusted Army Rate/100,000
White males	3.5	3.0	154,470	4.63	
White females	4.8	1.3	16,440	0.16	
Black males	7.7	41.4	69,010	28.29	
Black females	11.9	19.5	18,403	3.7	
Total	5.1	6.2	256,323	36.8	14.2

^a All non-Hispanic.

culosis rates among minorities could explain the rate disparity between the services. Alternatively, greater exposure risks encountered by U.S. Army soldiers, such as frequent deployments to highly endemic regions or greater personal contact with indigenous populations, also may account for the higher rates observed among U.S. Army enlisted personnel.

Racial Differences

U.S. Army tuberculosis rates varied markedly by racial groups compared with U.S. rates. Although all racial groups experienced a significant decline in rates, black and other minority hospitalization rates were two to five times greater than white rates throughout the study period. Because all military personnel are medically screened before enlistment and have equal access to health care services, results from this study highlight the potential impact that genetic susceptibility to *Mycobacterium tuberculosis* may have on inherently healthy populations. Differences in the efficiency of unstimulated alveolar macrophages to clear the bacilli and variations in human leukocyte antigen phenotypes are two hypothesized mechanisms that may explain the racial differences.¹¹⁻¹³ Although other more elusive factors linked to socioeconomic status may play a role in tuberculosis race disparities, they do not explain why racial differences persisted even among the officers. The persistent difference between the races also may reflect a difference in childhood exposure not detected with initial tuberculosis screening upon entrance into the military.

Rank (enlisted versus officer), like race, may serve as a surrogate for risk factors linked to socioeconomic status. Although enlisted personnel are, on average, 8 years younger than officers, and increasing age is a major risk factor for tuberculosis, enlisted personnel were still two to four times more likely to develop active tuberculosis. This finding is consistent with previous studies linking median household income to the incidence of tuberculosis. In 1994, Cantwell et al. found a 7-year averaged incidence rate of 4.2/100,000 population for the highest median household income group (midpoint, \$27,000) and 33/100,000 population for those in the lowest median household income group (midpoint, \$8,300).¹⁴ Set in more disadvantaged neighborhoods, the hometown communities of the U.S. Army's enlisted personnel may serve as a larger reservoir of *M. tuberculosis* infection, putting them at greater risk of exposure. Other factors, such as education, compliance with treatment and preventive measures, and varying racial compositions, may further account for the disparities noted in tuberculosis rates by rank.

Gender Differences

In contrast to the significant downward trend noted among male soldiers, no significant decline was detected among females for tuberculosis hospitalization rates during the 17-year study period. The small number of cases among females may have precluded detection of significant trends in this study. However, from 1990 through 1996, female rates stratified by black and white racial categories were notably greater than male rates, significantly for those aged 20 to 34 years. Although not stratified by race, a 1987 study of tuberculosis in the U.S. Air Force also found active duty female rates higher than male rates.¹⁵ A U.S. Navy study of tuberculosis among enlisted personnel found only black females exhibiting higher hospitalization rates than their male counterparts.⁹

These findings are not in keeping with general U.S. trends. According to a 1996 report produced by the CDC's Division of Tuberculosis Elimination, black and white female tuberculosis incidence rates were equal to or less than male rates for all ages older than 15 years.⁶ A greater percentage of females working in medical settings in the Army may help explain part of this gender discrepancy noted since 1990.

As shown in Figure 2, tuberculosis hospitalization rates stratified by race increased for both sexes from 1989-1990 to 1991-1992. This increase reached statistical significance ($p = 0.005$) for female soldiers. Although small case numbers among the females could have contributed to the instability of the rates, an alternative explanation may be the role of psychosocial factors such as stress and development of disease. It is widely recognized that both acute and chronic stress affect the immune system. Stress hormones such as glucocorticoids and catecholamines have been shown to suppress cellular immunity through their effects on T helper cell (type 1) functioning.¹⁶ In August 1990, the U.S. Army was anticipating the Persian Gulf War, with troops actually deploying in the autumn of 1990. The notable increase in tuberculosis cases in 1991 at the time of the war's commencement lends plausibility to the notion of a stress-induced reactivation of latent infection.

Other Potential Risk Factors

Although tuberculosis rates by hospital location have been declining since 1980, the U.S. Army hospital located in South Korea consistently exhibited greater rates than those in the United States and Germany. U.S. military hospitals may serve as referral centers for numerous U.S. Army installations located throughout the world; therefore, these results should be viewed

with caution. However, the increased risk of tuberculosis in the Pacific Rim has been documented previously.¹⁷ A study conducted among U.S. Air Force personnel reported positive PPD rates for nonflyer active duty personnel (per 1,000 persons screened) of 14.2, 18.3, and 23.6 for the Atlantic, U.S., and Pacific regions respectively.¹⁵ In 1996, the CDC reported an overall incidence of 41.6/100,000 for the Asian population in the United States.⁸ An increased risk of exposure attributable to Asia's high tuberculosis rate may explain the increased rates noted in the U.S. Army's hospital in Korea. In addition, individuals desiring deployment to Korea may have been exposed previously by family members or significant others with ties to the region.

Twenty-one of the 936 (2.2%) identified tuberculosis patients also were infected with HIV. Because of the aggressive destruction of CD4 T lymphocytes by the virus, HIV increases the risks of reactivation of latent tuberculosis infection and dissemination of primary tuberculosis.^{18,19} Progression to active disease has been estimated to increase from 10% per lifetime to 10% annually in those infected with both *M. tuberculosis* and HIV.²⁰ In a match of U.S. case registries, 14% of all tuberculosis cases reported from 1993 to 1994 were among patients concurrently infected with HIV.¹ This percentage nearly doubled among patients in the 25- to 44-year age group. The effect of HIV infection on active tuberculosis is not as prominent in the U.S. Army because military applicants found to be HIV-positive are barred from military service and active duty members testing HIV-positive during biennial screens are prohibited from overseas deployment,⁵ thereby decreasing their probability of exposure to tuberculosis.

Conclusions

Results presented in this study suggest that females and minorities are at greatest risk for tuberculosis among active duty U.S. Army personnel. Being stationed in Korea may also serve as a risk factor for active tuberculosis. Participation in multinational peacekeeping missions does not appear to have increased active tuberculosis in the U.S. Army. The U.S. Army's current tuberculosis control program has maintained similar rates among whites and actually decreased the rates among blacks compared with the general population.⁸ Through continual reassessment and monitoring of its current surveillance and control strategies, the U.S. Army will preserve its present low rate of active tuberculosis.

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