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BRIEF COMMUNICATION

Trends in Mortality of Tuberculosis Patients in the United States: The Long-Term Perspective

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PURPOSE: To describe long-term trends in tuberculosis (TB) mortality and to compare trends estimated from two different sources of public health surveillance data.
METHODS: Trends and changes in trend were estimated by joinpoint regression. Comparisons between data sets were made by fitting a Poisson regression model.
RESULTS: Since 1900, TB mortality rates estimated from death certificates have declined steeply, except for a period of no change in the 1980s. This decade had long-term consequences resulting in more TB deaths in later years than would have occurred had there been no flattening of the trend. Recent trends in TB mortality estimated from National Tuberculosis Surveillance System (NTSS) data, which record all-cause mortality, differed from trends based on death certificates. In particular, NTSS data showed TB mortality rates flattening since 2002.
CONCLUSIONS: Estimates of trends in TB mortality vary by data source, and therefore interpretation of the success of control efforts will depend on the surveillance data set used. The data sets may be subject to different biases that vary with time. One data set showed a sustained improvement in the control of TB since the early 1990s whereas the other indicated that the rate of TB mortality was no longer declining.
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KEY WORDS: Tuberculosis, Mortality, Trends, United States, Surveillance.

INTRODUCTION

Tuberculosis (TB) incidence has been falling for the past 150 years in North America and Europe (1, 2). The mortality associated with TB in the United States has dropped rapidly since 1900, especially since the 1940s when new antituberculous drugs became available (3, 4).

Mortality in patients with TB in the United States has been estimated from death certificates since the beginning of the 20th century. However, death certificates may not give reliable estimates of mortality for specific diseases, especially for respiratory and infectious diseases (5, 6). TB mortality rates since 1993 can also be estimated from the National Tuberculosis Surveillance System (NTSS) that has been collecting data on confirmed deaths of patients diagnosed with active TB disease. NTSS mortality data includes all deaths of TB patients including deaths that occurred just before TB diagnosis or during treatment.

We evaluated TB mortality in the United States from 1900 to 2006 using death certificate data to put recent trends in TB mortality in a long-term perspective. In addition, we compared recent trends in TB mortality estimated from death certificates and the NTSS to confirm that different surveillance systems give similar estimates of trends.

METHODS

Data

Numbers of deaths associated with TB on death certificates were taken from two sources: (1) Iskrant and Rogot (7) for 1900 to 1950; and (2) national estimates by the National Center for Health Statistics, National Vital Statistics Reports from 1953 to 2006 (8). These figures were used to show the long-term trends in deaths associated with TB in the United States from 1900 through 2006.

The NTSS provided data on the number of deaths from all causes among TB patients in the United States from 1993 to 2006. The NTSS is a nationally standardized system

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Selected Abbreviations and Acronyms

CDC = Centers for Disease Control and Prevention
NTSS = National Tuberculosis Surveillance System
TB = Tuberculosis

through which state health departments report all known TB cases to the CDC using fixed criteria (Report of a Verified Case of Tuberculosis), and includes both culture proven and clinically proven cases (9). It provides comprehensive data on all patients but overestimates mortality associated with TB because it records deaths from all causes. NTSS mortality data included deaths that had occurred by the time the diagnosis of TB was confirmed, called "death by diagnosis" (10), and those who died from all causes during their TB therapy, called "death during treatment" (9). We included all deaths in the NTSS database in this analysis. For all years we used census estimates of population size for the United States (11).

Long-term TB Mortality Trends

We plotted trends in TB mortality from death certificate data on a logarithmic scale to illustrate trends in the United States from 1900 to 2006. Mortality was expressed as log (deaths per million) on the graphs to avoid negative numbers. Trends in TB mortality (the number of deaths per 100,000 population), and the years of inflection when trends changed, were estimated by joinpoint regression (12). This is a method for identifying joinpoints, or significant changes in trend, using permutation tests (12). A phase was defined as the years between two inflections when the trend was constant. The joinpoint regression model was only fitted to the data from 1953 to 2006 because those were the years for which contiguous data were available.

Comparison of Death Certificate and NTSS Data Sets

To compare mortality trends based on death certificate versus NTSS data, we fitted a Poisson regression model with three predictor variables: time (continuous), data source (binary), and phases defined by the joinpoint regression (categorical). Number of deaths was used for the response variable and the log of population size was the offset. An adjustment was made for overdispersion (13). Time was represented by years centered on the midpoint of the period covered by the model. The interaction of time by phase accounted for differences between phases. The interaction of time by data set tested the hypothesis that the rate of change (or trend) in mortality was similar for both data sets. Interaction terms were evaluated with the likelihood ratio test (14).

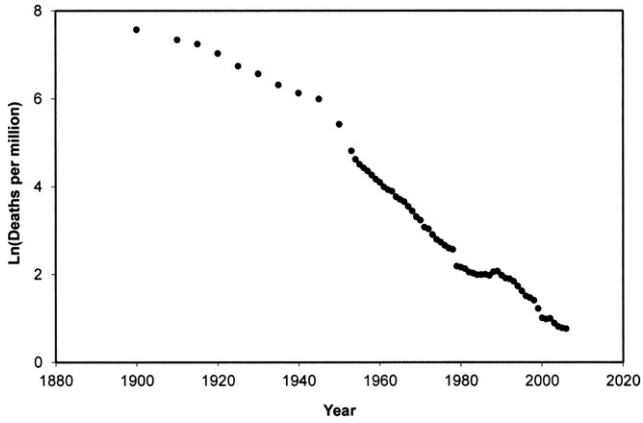

FIGURE 1. Trends in TB mortality rates in the United States from 1900 through 2006 based on death certificates, shown on a logarithmic scale.

RESULTS

Long-term TB Mortality Trends

During the first half of the 20th century, TB mortality fell steadily and then more rapidly (Fig. 1). The steep decline was interrupted by a marked flat phase between 1982 and 1990 (Fig. 1 and Table 1). We projected the number of deaths that would have occurred if rates continued to decline and compared it to the actual number of deaths. In the absence of a flat phase, we projected that the total TB deaths between 1982 and 2006 would have been 21,004 (Fig. 2). The recorded total during that time was 33,567 deaths—a difference of 60%. In the absence of a flat phase, there would have been 297 deaths in 2006, compared to the 644 that were recorded for that year—a difference of 117%.

TABLE 1. Trends in mortality associated with TB estimated by joinpoint regression from two sets of surveillance data

Variable	Data set	Phase*	Annual % change (95% CI)
TB mortality since 1953	Death certificates	1953–1955	−14.2 (−18.6, −9.5)
		1955–1966	−7.5 (−8.0, −7.0)
		1966–1982	−9.5 (−10.0, −9.1)
		1982–1990	0.1 (−2.1, 2.4)
		1990–2006	−8.2 (−9.0, −7.4)
TB mortality since 1993	NTSS	1993–2002	−13.3 (−13.8, −12.9)
		2002–2006	−3.4 (−5.8, −0.9)

CI = confidence interval; NTSS = National Tuberculosis Surveillance System; TB = tuberculosis.
*Phases were defined as the years between the inflection points identified by the joinpoint regression.