The epidemiology of spinal tuberculosis in the United States: an analysis of 2002–2011 data

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OBJECTIVE The aim of this study was to investigate the incidence of spinal tuberculosis (TB) in the US between 2002 and 2011.

METHODS The Nationwide Inpatient Sample database from 2002 to 2011 was used to identify patients with a discharge diagnosis of TB and spinal TB. Demographic and hospital data were obtained for all admissions, and included age, sex, race, comorbid conditions, insurance status, hospital location, hospital teaching status, and hospital region. The incidence rate of spinal TB adjusted for population growth was calculated after application of discharge weights.

RESULTS A total of 75,858 patients with a diagnosis of TB were identified, of whom 2789 had a diagnosis of spinal TB (3.7%); this represents an average of 278.9 cases per year between 2002 and 2011. The incidence of spinal TB decreased significantly—from 0.07 cases per 100,000 persons in 2002 to 0.05 cases per 100,000 in 2011 ($p < 0.001$), corresponding to 1 case per 2 million persons in the latter year. The median age for patients with spinal TB was 51 years, and 61% were male; 11.6% were patients with diabetes, 11.4% reported recent weight loss, and 8.1% presented with paralysis. There were 619 patients who underwent spinal surgery for TB, with the most common location being the thoracolumbar spine (61.9% of cases); 50% of patients had instrumentation of 3 or more spinal segments.

CONCLUSIONS During the examined 10-year period, the incidence of spinal TB was found to significantly decrease over time in the US, reaching a rate of 1 case per 2 million persons in 2011. However, the absolute reduction was relatively small, suggesting that although it is uncommon, spinal TB remains a public health concern and most commonly affects male patients approximately 50 years of age. Approximately 20% of patients with spinal TB underwent surgery, most commonly in the thoracolumbar spine.

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KEY WORDS tuberculosis; spine; Pott's disease; epidemiology; incidence; surgery; infection

SPINAL tuberculosis (TB) is a known cause of spinal deformity and paraplegia. First described in the modern era by English surgeon Percival Pott in 1779 (i.e., Pott's disease),²⁰ it is currently regarded as a disease affecting people in the developing world.⁷ Nevertheless, TB remains a problem in developed regions such as Europe and the US.^{6,16,25} In 2014 alone, a total of 9421 new cases of TB were reported in the US, corresponding to an incidence of 2.96 cases per 100,000 persons.⁵

Pott was the first to recognize the link between TB, ky-

phosis, and paraplegia.¹² Whereas spinal TB affects mostly children in developing nations, it is a disease of the elderly in the developed world.⁷ Pott's disease develops after hematogenous spread of *Mycobacterium tuberculosis* from a primary site (typically the lungs), which leads to destruction of the intervertebral disc and vertebral body.¹¹ This results in a pathological compression fracture, vertebral wedging, and kyphoscoliosis, which in turn may lead to neurological deficits due to spinal cord compression.^{2,14,17}

Despite multiple epidemiological studies examining

ABBREVIATIONS ICD-9 = *International Classification of Diseases, 9th Revision*; LOS = length of stay; NIS = Nationwide Inpatient Sample; TB = tuberculosis.

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FIG. 1. Graph showing the population growth-adjusted incidence rate of patients with a discharge diagnosis of spinal TB in the US from 2002 to 2011. After a peak in 2003, the incidence was found to decrease significantly over time ($p < 0.001$). Figure is available in color online only.

TB, there are limited data on the prevalence of Pott's disease in the US.^{9,13} The aim of this study is to investigate the incidence of spinal TB in the American population between 2002 and 2011, using a large nationwide database.

Methods

Study Design

This epidemiological study used the Nationwide Inpatient Sample (NIS) database records of patients treated between 2002 and 2011. Developed by the Healthcare Cost and Utilization Project, the NIS is the largest inpatient database in the US, containing hospital admission information from a 20% sample of community hospitals across the country. This 20% sample corresponds to more than 8 million hospital stays annually and contains diagnostic and procedure data in the form of *International Classification of Diseases, 9th Revision* (ICD-9) codes.

Patient Sample and Inclusion Criteria

All patients with a diagnosis of "tuberculosis" were identified using the Clinical Classifications Software code #1. Patients with spinal TB were then identified via use of ICD-9 codes 015.00, 015.01, 015.02, 015.03, 015.04, 015.05, and 015.06. Patients who underwent spinal fusion were identified via ICD-9 procedural codes 81.00–81.09.

Recorded Variables

Documented admission information included the following: patient age; sex; race; comorbid conditions; primary payer (insurance); hospital region (Northeast, Midwest or North Central, South, or West); hospital teaching status; hospital location (urban vs rural); in-hospital mortality rate; and length of stay (LOS). For patients who underwent spinal surgery, the following complications were recorded: neurological complications; iatrogenic stroke; respiratory complications (including respiratory failure); pulmonary embolism; deep venous thrombosis; myocardial infarction; acute kidney injury; urinary tract infection; *Clostridium difficile*; paralytic ileus; other gastrointestinal

FIG. 2. Bar graph showing the proportion of patients with spinal TB among all TB cases. The proportion was found to decrease significantly, from 4.1% in 2002 to 2.6% in 2011 ($p < 0.001$). Figure is available in color online only.

complication; surgical site infection; meningitis; pneumonia; and incidental durotomy. Hospital charges (excluding professional fees) were also recorded and reported in 2016 US dollars.

Statistical Methods

National estimates for spinal TB cases were calculated after application of discharge weights supplied by the NIS. Given that this database is a 20% sample, roughly a 5-fold multiplication will give the total number of estimated cases in the US per year. US population data for each year were obtained from the website of the US Census Bureau (<http://www.census.gov/popest/data/historical/index.html>). Incidences for any given year were adjusted for population growth by dividing the estimate of each diagnosis (from the NIS) by the total population estimate from the US Census Bureau.⁴ A simple linear regression was done to analyze trends over time. Statistical analyses were performed in STATA 12 SE (StataCorp). A probability value < 0.05 was considered statistically significant.

Results

Between 2002 and 2011, a total of 75,858 patients with a diagnosis of TB were identified, of whom 2789 had a diagnosis of spinal TB (3.7%). The average annualized rate of spinal TB was 278.9 cases per year. During the 10-year period examined, the incidence of spinal TB decreased significantly, from 0.07 cases per 100,000 persons in 2002 to 0.05 per 100,000 in 2011 (Fig. 1). In 2011, this incidence corresponded to 1 case per every 2 million persons.

The proportion of spinal TB cases among all TB cases was 4.1%, 5.6%, 3.3%, 3.8%, 2.6%, 3.7%, 4.0%, 4.0%, 3.0%, and 2.6% yearly between 2002 and 2011 (Fig. 2). A summary of spinal TB cases is shown in Table 1. The median age of patients was 51 years, and 61% were male. There was an almost equal proportion of Caucasian (24.0%), African American (23.8%), and Hispanic patients (23.2%), and a smaller proportion of Asian/Pacific Islanders (18.8%) and others (10.2%). The 5 most common

TABLE 1. Summary of characteristics in 2789 patients with a diagnosis of spinal TB

Parameter	Value
No. of cases	2789
Median age in yrs (IQR)	51 (35–65)
Age >65 yrs (%)	24.4
Sex (%)	
Female	39.0
Male	61.0
Race (%)	
Caucasian	24.0
African American	23.8
Hispanic	23.2
Asian or Pacific Islander	18.8
Other	10.2
Comorbidities (%)	
Alcohol abuse	3.0
Chronic lung disease	7.7
Diabetes	11.6
Drug abuse	5.5
Hypertension	28.6
Liver disease	4.9
Obesity	2.8
Renal failure	5.6
Paralysis	8.1
Weight loss	11.4
HIV positive	4.0
Malnutrition	11.6
Insurance status (%)	
Medicare	25.8
Medicaid	24.4
Private insurance	26.2
Self-pay	11.4
Other	12.2
Hospital region (%)	
Northeast	22.6
Midwest or North Central	10.1
South	39.9
West	27.4
Teaching hospital (%)	76.8
Urban hospital (%)	97.7
In-hospital mortality (%)	1.9
Median LOS in days (IQR)	10 (6–19)

IQR = interquartile range.

comorbid conditions were hypertension (28.6%), diabetes (11.6%), malnutrition (11.6%), weight loss (11.4%), and paralysis (8.1%); 4.0% of patients were HIV positive. More than one-fourth (26.2%) of patients had private insurance, 25.8% had Medicare, 24.4% had Medicaid, 12.2% had another form of insurance, and 11.4% were categorized as self-pay.

The most common hospital region was the South

TABLE 2. Summary characteristics of 619 patients who underwent surgery for spinal TB between 2002 and 2011

Parameter	Value
No. of cases	619
Median age in yrs (IQR)	52 (35–66)
Age >65 yrs (%)	26.2
Sex (%)	
Female	44.4
Male	55.6
Surgery location (%)	
Cervical	11.1
Thoracolumbar	61.9
Lumbosacral	27.0
Approach (%)	
Posterior only	38.9
Anterior only	26.6
Combined	34.5
No. of instrumented levels (%)	
1–2	50.0
3–7	42.0
≥8	8.0
Complication rate (%)	38.8
In-hospital mortality (%)	3.2
Median LOS in days (IQR)	16 (10–24)

(39.9%), followed by the West (27.4%), the Northeast (22.6%), and the Midwest or North Central (10.1%). A majority of patients were admitted to urban hospitals (97.7%) with teaching status (76.8%). The in-hospital mortality rate was 1.9%, and the median LOS was 10 days.

There were 619 patients who underwent spinal surgery for TB (22.2% of spinal TB cases) (Table 2), with a median age at surgery of 52 years; 55.6% were male. The most common location was the thoracolumbar spine (61.9% of cases), and 50% of patients had instrumentation of 3 or more spinal segments. The surgical approach was posterior alone in 38.9% of cases, anterior alone in 26.6%, and combined in 34.5%. The mortality rate was 3.2%, and the median LOS was 16 days. The percentage of patients who developed at least 1 in-hospital complication was 38.8%. The proportion of patients with spinal TB who required surgery was 23.1%, 20.0%, 13.6%, 16.9%, 23.4%, 25.4%, 32.2%, 16.4%, 20.5%, and 18.9% between 2002 and 2011 ($p = 0.426$). The average adjusted hospital charges for patients who required surgery were \$223,780 ± \$168,361, versus \$55,363 ± \$72,998 for patients with spinal TB who did not require surgery ($p < 0.001$).

Discussion

Although the first modern description of spinal TB was published in 1779, the first evidence of this disease dates to a skeleton from approximately 5000 BC.¹² Nowadays, Pott's disease mostly affects children and young adults in developing countries,^{17,18} and may cause severe spinal deformity and associated paraparesis secondary to cord compression

FIG. 3. A 21-year-old woman, an immigrant, presented to our institution with a severe kyphotic deformity of the thoracic spine and mild paraparesis secondary to TB. **Left:** Preoperative CT scan of the thoracic spine showing destruction of T-7, T-8, and T-9, with severe focal kyphosis. **Right:** Preoperative T2-weighted MR image showing focal kyphotic deformity and spinal cord compression.

(Fig. 3). Nonetheless, spinal TB is still seen in vulnerable populations in the developed world, including Europe and the US. The aim of this study was to investigate the incidence of Pott's disease in America, and although we found a statistically significant decrease between 2002 and 2011, the absolute decrease was relatively small (from 0.07 per 100,000 persons to 0.05 per 100,000).

In 2002, there were an estimated total of 188 cases of spinal TB (0.07 per 100,000 persons), which peaked to 457 in 2003 (0.16 per 100,000 persons). Afterward, the total number of cases gradually decreased, reaching 155 cases in 2011, which corresponds to 0.05 per 100,000, or 1 per 2 million persons. Patients with spinal TB were on average 51 years of age, and 61% were male. Commensurate with our findings, Brashear and Rendelman also reported an average age of 51 years in a series of patients with spinal TB from the southern US.³ Schlesinger et al. examined 12 patients with Pott's disease from a New Jersey hospital (Northeast US), finding a mean age of 40 years and male predominance (58%).²²

The prevalence of HIV positivity was 4.0% in the present study, and 5.5% of patients had a history of drug abuse. Similar to these findings, Fuentes Ferrer et al. performed a systematic review of spinal TB case series, finding a median prevalence of HIV of 7.5%.¹⁰ On the other hand, more than one-tenth of patients in our study presented with diabetes, malnutrition, and/or weight loss, all of which have been associated with spinal TB.^{10,15,23}

Interestingly, the most common hospital regions were the southern US in almost 40% of cases, followed by the western US in 27.4%. Similar to these findings, the official report from the Centers for Disease Control and Prevention found a higher than average incidence for states such as Texas, Florida, Georgia, California, and Nevada.⁵ These aforementioned states had an incidence of > 3 cases per 100,000 persons, which was higher than the national average of ≤ 3 cases per 100,000. Although there is no single explanation for these findings, contributing factors to the observed higher incidence in these states include a larger proportion of patients who were foreign born and higher rates of homelessness, among others.¹

In the present study, 22.2% of spinal TB cases required surgery, with the most common location being the thoracolumbar spine in 61.9% of cases, followed by the lumbosacral spine in 27.0%, and the cervical spine in 11.1%. With the availability of systemic antituberculous therapy, surgery for spinal TB is reserved for patients with neurological deficits, instability due to kyphoscoliotic deformity, drug-resistant TB, or those in whom there is a high risk of paralysis.²¹ In a randomized controlled trial performed in the United Kingdom, researchers randomized patients with spinal TB to 1 of 3 groups: A) surgery plus 6 months of isoniazid plus rifampicin; B) isoniazid plus rifampicin for 6 months; or C) isoniazid plus rifampicin for 9 months.¹⁹ The authors found rates of "favorable status" in 90%, 94%, and 99% of patients in Groups A, B, and C, respectively. Nevertheless, patients younger than 15 years of age with kyphotic deformity greater than 30° did not experience as much improvement with medical therapy alone. Surgical techniques include posterior decompression and stabilization, anterior decompression and stabilization, and combined approaches (either posterior-anterior or anterior-posterior) with stabilization (Fig. 4).²¹

Although spinal TB is considered predominantly a disease affecting people in the developing world, the findings in the present study suggest that it is still seen in the US. The incidence of Pott's disease has slightly decreased, and the 2011 estimate was of 1 case per 2 million. Patients at the highest risk for TB (immunocompromised, malnourished, living in poverty, with a history of traveling to high-prevalence areas, and others) who present with back pain should be evaluated for the possibility of Pott's disease.

Study Limitations

This study has several limitations. Although the NIS database has been used in multiple studies examining the epidemiology and trends of various spinal disorders,^{4,8,24} its administrative nature carries a risk of coding bias. Given that it is an inpatient database, spinal TB cases treated in an outpatient setting are not captured, and thus the true incidence of spinal TB may be higher. The lack of data on functional status, degrees of kyphosis, or long-term outcome is also an important limitation. Nevertheless, this is one of the first studies to report the incidence of Pott's disease in a developed country, and the use of such a large database allows for adequate estimation of the incidence of rare conditions.

FIG. 4. The same patient depicted in Fig. 3 underwent a combined anterolateral-posterior approach. The first stage consisted of a right-sided thoracotomy, resection of rib, and corpectomy of T-7, T-8, and T-9. This was followed by placement of a distractible cage, plate, and screws, reduction of kyphosis, and arthrodesis using allograft and local autograft from T-6 to T-10. This was followed by drainage of abscess. The second stage consisted of pedicle screw instrumentation from T-3 to T-12 and arthrodesis performed using locally obtained autograft, allograft, and demineralized bone matrix. **Left:** Postoperative CT image showing the distractible cage between T-6 and T-10. **Right:** Postoperative radio-graph showing anterior and posterior reconstruction.

Conclusions

In this study of a nationwide database, the incidence of spinal TB was found to decrease significantly over time in the US, reaching a rate of 1 case per 2 million persons in 2011. However, the absolute reduction was relatively small, suggesting that although it is uncommon, spinal TB remains a public health concern most commonly affecting male patients approximately 50 years of age. Of all spinal TB cases, approximately 20% required surgery—most commonly in the thoracolumbar spine.

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Author Contributions

Conception and design: Sciubba, De la Garza Ramos. Acquisition of data: Sciubba, De la Garza Ramos, Goodwin. Analysis and interpretation of data: all authors. Drafting the article: all authors. Critically revising the article: Sciubba, De la Garza Ramos, Bydon, Witham, Wolinsky. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Sciubba. Statistical analysis: Sciubba, De la Garza Ramos, Goodwin, Abu-Bonsrah. Study supervision: Sciubba, Bydon, Witham, Wolinsky.

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