Human-to-cattle transmission of *Mycobacterium tuberculosis* complex species

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TB Controllers Webinar
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Mycobacterium Tuberculosis Complex (MTBC) species

- **Primary human pathogens**
  - M. tuberculosis
  - M. africanum
  - M. canetti

- **Primary animal pathogens**
  - M. bovis
  - M. orygis
  - M. caprae
BREAKING THE CHAIN OF TRANSMISSION
STOPPING ZOONOTIC AND BOVINE TUBERCULOSIS IN THEIR TRACKS

ZOOONOTIC TB IN PEOPLE

FOODBORNE
- Non-heat-treated dairy products
- Raw or improperly cooked meat from diseased animals

ONE HEALTH HUMANS, ANIMALS, ENVIRONMENT

DIRECT CONTACT

INFECTED WILDLIFE

DIRECT CONTACT OR CONTAMINATED ENVIRONMENT

BOVINE TB IN CATTLE

ACT NOW TO SAVE LIVES AND SECURE LIVELIHOODS

U.S. Department of Agriculture

Veterinary Services Animal and Plant Health Inspection Service World Health Organization OIE
Human TB Burden

Total Genotyped TB and *M. bovis* Cases

Number

Year


TB Cases  M. bovis Cases

Human TB Burden

Total Genotyped TB and *M. bovis* Cases

- **Number**
  - Total Genotyped TB and *M. bovis* Cases
  - Total *M. bovis* Cases
  - Linear (Total *M. bovis* Cases)

- **Year**
  - 2004 to 2019

Human TB Burden

Percent of *M. bovis* by Case Origin

Epidemiology of *Mycobacterium bovis* disease in San Diego County, 1994–2000

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Human Tuberculosis due to *Mycobacterium bovis* in the United States, 1995–2005

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Human Tuberculosis Caused by *Mycobacterium bovis* in the United States, 2006–2013

Colleen Scott,\(^1,2\) Joseph S. Cavanaugh,\(^2\) Robert Pratt,\(^3\) Benjamin J. Silk,\(^2\) Philip LoBue,\(^2\) and Patrick K. Moonan\(^2\)

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(See the Editorial Commentary by Fujivara and Olea-Poppelka on pages 602–3.)

**Background.** Using genotyping techniques that have differentiated *Mycobacterium bovis* from *Mycobacterium tuberculosis* since 2005, we review the epidemiology of human tuberculosis caused by *M. bovis* in the United States and validate previous findings nationally.

**Methods.** All tuberculosis cases with a genotyped *M. tuberculosis* complex isolate reported during 2006–2013 in the United States were eligible for analysis. We used binomial regression to identify characteristics independently associated with *M. bovis* disease using adjusted prevalence ratios (aPRs) and corresponding 95% confidence intervals (CIs).

**Results.** During 2006–2013, the annual percentages of tuberculosis cases attributable to *M. bovis* remained consistent nationally (range, 1.3%–1.6%) among all tuberculosis cases (N = 59,273). Compared with adults 25–44 years of age, infants aged 0–4 years (aPR, 1.9 [95% CI, 1.4–2.8]) and children aged 5–14 years (aPR, 4.0 [95% CI, 3.1–5.3]) had higher prevalences of *M. bovis* disease. Patients who were foreign-born (aPR, 1.4 [95% CI, 1.2–1.7]), Hispanic (aPR, 3.9 [95% CI, 3.0–5.0]), female (aPR, 1.4 [95% CI, 1.3–1.6]), and resided in US-Mexico border counties (aPR, 2.0 [95% CI, 1.7–2.4]) also had higher *M. bovis* prevalences. Exclusively extrapulmonary disease (aPR, 3.7 [95% CI, 3.3–4.2]) or disease that was both pulmonary and extrapulmonary (aPR, 2.4 [95% CI, 2.1–2.9]) were associated with a higher prevalence of *M. bovis* disease.

**Conclusions.** Children, foreign-born persons, Hispanics, and females are disproportionately affected by *M. bovis*, which was independently associated with extrapulmonary disease. Targeted prevention efforts aimed at Hispanic mothers and caregivers are warranted.

**Keywords.** *Mycobacterium bovis*; tuberculosis; epidemiology; trends.
Human Tuberculosis Caused by *Mycobacterium bovis* in the United States, 2006–2013

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- Prevalence higher in
  - Foreign born, Hispanics, children (5-14 yrs.), and women
- Clinical Presentation

<table>
<thead>
<tr>
<th>Lesion Location</th>
<th><em>M. bovis</em></th>
<th><em>M. tuberculosis</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Extrapulmonary only</td>
<td>43.6%</td>
<td>15.6%</td>
</tr>
<tr>
<td>Pulmonary only</td>
<td>35.4%</td>
<td>74.3%</td>
</tr>
<tr>
<td>Both</td>
<td>21.0%</td>
<td>10.1%</td>
</tr>
</tbody>
</table>
ARS slide of Reduction in TB Infected Animals. (1960 USAHA TB Report)
ARS slide of Reduction in TB Infected Animals. (1960 USAHA TB Report)

**Figure I**

*Bovine Tuberculosis*

**INFECTED ANIMALS (CALCULATED)**

- **1917**: 5% of 3,229,000
- **1940**: 0.46% of 314,000
- **1954**: 0.11% of 104,000
- **1960**: 0.15% of 152,280
- **2021**: 0.000061% of 61 head

99.99% decrease!!

Slide courtesy of Dr. Mark Camacho
The incidence of new cases of TB in the US is low, and relatively stable (upward trend), since 1990.
Each section of this pie-chart is a unique WGS of *M. bovis*.

Since 1998, the US has had 175 affected herds.

Without Michigan, the number is 91 affected herds with 42 unique, “never-before seen” TB strains in 23 years.

*M. bovis* Sources??
- Humans?
- Unknown cattle movements?
- Low level (percolating) infection in the US cattle herd?
- Import of infected Mexican cattle (feeders/ropers)?

That is **1.8 NEW WGSs per year in US cattle!**

Where are these new TB strains coming from?... And why do they keep occurring on a regular basis?

Slide courtesy of Dr. Mark Camacho
M. bovis Positive Cattle from Slaughter Surveillance, FY 2001–2021¹

1 511 total cases including 82 in adult cattle; 429 cases in fed cattle including 320 cases (74%) in Mexican origin fed cattle

Slide courtesy of Dr. Mark Camacho
Published U.S. cases

• 1942 – Tice, Cornell Vet (1944)
  • Owner contracted bovine TB (*M. bovis*) from original herd, developed pulmonary TB, subsequently infected 4 herds in 2.5 years
Published U.S. cases

• 1966 – Baldwin, Cornell Vet (1968)

B. McCluskey\textsuperscript{a,*}, J. Lombard\textsuperscript{b}, S. Strunk\textsuperscript{b}, D. Nelson\textsuperscript{c}, S. Robbe-Austerman\textsuperscript{d}, A. Naugle\textsuperscript{e}, A. Edmondson\textsuperscript{f}

<table>
<thead>
<tr>
<th>Herd</th>
<th>Source of infection</th>
<th>Detection method</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Unknown</td>
<td>Slaughter surveillance</td>
</tr>
<tr>
<td>B</td>
<td>Purchase of infected cattle from Herd A – probable</td>
<td>Trace from Herd A</td>
</tr>
<tr>
<td>C</td>
<td>Unknown</td>
<td>Slaughter surveillance</td>
</tr>
<tr>
<td>D\textsuperscript{a}</td>
<td>Purchase of infected cattle from Herd E</td>
<td>Slaughter surveillance</td>
</tr>
<tr>
<td>E</td>
<td>Unknown</td>
<td>Trace from Herd D</td>
</tr>
<tr>
<td>F</td>
<td>Purchase of infected cattle from Herd E</td>
<td>Trace from Herd E</td>
</tr>
<tr>
<td>G</td>
<td>Unknown</td>
<td>Trace from Herd E</td>
</tr>
<tr>
<td>H</td>
<td>Unknown</td>
<td>Trace from Herd G</td>
</tr>
<tr>
<td>I</td>
<td>Unknown</td>
<td>Slaughter surveillance</td>
</tr>
<tr>
<td>J</td>
<td>Unknown</td>
<td>Slaughter surveillance</td>
</tr>
<tr>
<td>K</td>
<td>Contact with infected cattle from Herd J</td>
<td>Trace from Herd J</td>
</tr>
<tr>
<td>L</td>
<td>Contact with infected cattle from Herd A–probable</td>
<td>Slaughter surveillance</td>
</tr>
</tbody>
</table>
What has changed?
Recent U.S. cases

- North Dakota dairy herd
  - 2013
- Wisconsin dairy herd
  - 2015-2021
- Texas dairy heifer
  - 2018
North Dakota Dairy – 2013

- Dairy employee infected with *M. bovis* and alerted to State Ag by Public Health in October 2013
- Herd volunteered for testing in November 2013
  - > 6 months of age tested
    - 319 tested; 11 Caudal fold tuberculin (CFT) test responders; 1 comparative cervical tuberculin (CCT) test suspect
      - 1 CCT suspect – necropsy –
        - Severe pneumonia with purulent abscesses
        - Mediastinal LN multiple micro abscesses
        - Culture POSITIVE
    - 10 CFT responder – slaughter
      - 1 cow was culture POSITIVE/PCR negative
      - 1 cow was culture negative/PCR POSITIVE
• WGS of employee and one cow matched
• ND investigation concluded:

“...employee was most likely infected and spread the disease to the cattle.”
Wisconsin Dairy – 2015-20

• Infected dairy worker alerted to DATCP by DHS in April 2015, employed Jan – Mar 2015

• Herd volunteered for testing in May 2015
  • ~1500 tested; 31 CFT responders, 1 CCT suspect
    • CCT suspect – necropsy – NEGATIVE
  • Repeat testing in September 2015, 0 CCT suspects
Wisconsin Dairy – 2015-20

• Slaughter plant – 2018
  • Lesion – POSITIVE
  • Traced back to WI dairy, testing repeated
    • ~2000 tested (≥2 mo old): 48 CFT responders; 10 CCT S/R
    • 12 infected cows detected to date
Wisconsin Dairy – 2015-20
WGS of employee was very close to strains in cows
Texas dairy-cross heifer – 2018

- Transported from NM at 1 day of age, raised at a heifer raising facility in TX
- CFT responder and CCT reactor → necropsy
  - *Mycobacterium tuberculosis*

Doesn’t normally occur in cattle, human exposure
Published U.S. cases

- North Dakota dairy herd
  - 2013
- Wisconsin dairy herd
  - 2015-2021
- Texas dairy heifer
  - 2018
What about other countries?
Number of Published Studies by MTBC Species and Decade Published

![Graph showing the number of published studies by MTBC species and decade.]

- **M. tuberculosis**
- **M. bovis**
- **Combination/other**
**Mycobacterium bovis** tuberculosis: from animal to man and back

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**SUMMARY**

Rare cases of tuberculosis due to *Mycobacterium bovis* have been described in humans who have been exposed to cattle or other infected animals. We report a case of tuberculosis in cattle exposed to a patient infected with *M. bovis*, where the strain isolated in the cattle and the patient were identical. As the patient is reported to have been exposed and contaminated during childhood, this seems to be the first documented case of transmission of *M. bovis* from animal to man and back to animal.

**KEY WORDS:** *M. bovis* tuberculosis; animal tuberculosis; contamination
Transmission of *Mycobacterium tuberculosis* from Human to Cattle

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Received 15 September 2004/Returned for modification 29 November 2004/Accepted 3 April 2005

We describe the first transmission of *Mycobacterium tuberculosis* from human to cattle confirmed by molecular typing of isolates involved in the transmission. IS6110-based restriction fragment length polymorphism analysis showed that the isolates from the cattle and farm worker who suffered from pulmonary tuberculosis 1 year prior to this case were the same strains.
Transmission of *Mycobacterium orygis* (M. tuberculosis Complex Species) from a Tuberculosis Patient to a Dairy Cow in New Zealand

Kara L. Dawson,a Anita Bell,b R. Pamela Kawakami,c Kathryn Coley,b Gary Yates,c and Desmond M. Collinsc

Animal Health Board, Wellington, New Zealand; Waikato District Health Board, Hamilton, New Zealand; and AgResearch, NCBID Wallaceville, Upper Hutt, New Zealand

*Mycobacterium orygis,* previously called the oryx bacillus, is a member of the *Mycobacterium tuberculosis* complex and has been reported only recently as a cause of human tuberculosis in patients of South Asian origin. We present the first case documenting the transmission of this organism from a human to a cow.
Short Communication

*Mycobacterium tuberculosis* infection in grazing cattle in central Ethiopia

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**ABSTRACT**

A preliminary study to characterise mycobacteria infecting tuberculous cattle from two different management systems in central Ethiopia was carried out. Approximately 27% of isolates from grazing cattle were *Mycobacterium tuberculosis*, while cattle in a more intensive-production system were exclusively infected with *M. bovis*. The practice of local farmers discharging chewed tobacco directly into the mouths of pastured cattle was identified as a potential route of human-to-cattle transmission of *M. tuberculosis*.

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“The practice of local farmers discharging chewed tobacco directly into the mouths of pastured cattle was identified as a potential route of human-to-cattle transmission of *M. tuberculosis.*”

Fig. 1. A farmer in central Ethiopia discharging tobacco juice directly into the oral cavity of his cattle, a common practice in this region and a possible route of transmission of *Mycobacterium tuberculosis* from humans to cattle.
SPECIAL ARTICLE

Bovine tubercle bacilli and disease in animals and man

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Cardiothoracic Institute, Fulham Road,
London SW3 6HP.

Proven cases of transmission of bovine tubercle bacilli from man to cattle have been reported (Leslie, 1968; Lepper & Corner, 1983). Although transmission is often via the respiratory route, a number of cases of cross-infection resulted from attendants urinating on the hay. This, we are credibly informed, is a common practice and is said to provide a source of salt in the cows’ diet! Huitema (1969) reported 50 examples of herds infected from human sources and in 24 cases the responsible individual had renal tuberculosis. Many of these patients, especially the older ones, had clear chest radiographs and only vague symptoms. Diagnosis was thus often delayed until many animals had been infected. As noted above, urinary tract infection is nowadays one of the more frequent manifestations of human tuberculosis due to bovine strains.
Figure 2. Anthropogenic tuberculosis in animals in contact with M. tuberculosis-infected human hosts.
BREAKING THE CHAIN OF TRANSMISSION
STOPPING ZOONOTIC AND BOVINE TUBERCULOSIS IN THEIR TRACKS

ZOONOTIC TB IN PEOPLE

FOODBORNE
- NON-HEAT-TREATED DAIRY PRODUCTS
- RAW OR IMPROPERLY COOKED MEAT FROM DISEASED ANIMALS

DIRECT CONTACT

ONE HEALTH
HUMANS, ANIMALS, ENVIRONMENT

INFECTED WILDLIFE

DIRECT CONTACT OR CONTAMINATED ENVIRONMENT

BOVINE TB IN CATTLE

ACT NOW TO SAVE LIVES AND SECURE LIVELIHOODS
Conclusions

• U.S. cattle herds continue to become infected
• Source is unknown for more than 40%
• Three relatively recent U.S. cases show evidence of human-to-cattle transmission of MTBC species
• Multiple reports of human-to-cattle transmission of MTBC species from around the world
• One Health approach needed to address this issue
Activities

• National Milk Producers Federation TB Working Group
  • Led by Miquela Hanselman and Jamie Jonker
  • Animal and public health, industry, producers
  • Best practices for human-to-cattle TB transmission issues
    • Effectively communicate the risk to public health
    • Communication between animal and public health when TB is detected
    • Managing risk of human-to-cattle transmission on dairies
      • Testing of employees
Thank You!

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