

Tracking the spread of tuberculosis in Brazilian prisons

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An incarcerated man undergoes a chest x-ray in a mobile screening unit to test for tuberculosis. Credit: Andrea Santos

COVID-19 has nothing on tuberculosis. The bacterial infection has ravaged humanity for thousands of years—accounting for one quarter of all deaths in the United States and Europe for 300 years before the discovery of antibiotics.

It is still rampant in developing countries and in crowded conditions, and it still kills more than 1 million [people](#) annually.

Over the past several years, Jason Andrews, MD, associate professor of infectious disease, has led a team to investigate the transmission of tuberculosis in Brazilian prisons. He hopes to understand the role prisons play in the spread of the disease to surrounding communities and to identify the best way to screen and treat incarcerated individuals who often live in rooms with dozens of people.

"When we began the study, the burden of tuberculosis in prisons was not well understood," Andrews said. "The World Health Organization comes up with global estimates every year to help scientists and policymakers understand the spread of tuberculosis in countries. But they don't report the incidence of tuberculosis in incarcerated populations, even though being incarcerated is one of the strongest risk factors for tuberculosis globally. We wanted to address that knowledge gap."

Addressing that gap took a team of people from Stanford, Yale and Brazil. And a lot of ingenuity. The researchers transformed a large truck confiscated by Brazilian police from a local drug trafficker into a mobile screening unit, complete with the latest diagnostic equipment, including X-rays and laboratory equipment. They also partnered with leaders in the incarcerated population to obtain samples from surfaces within the prison that the researchers couldn't safely access. Finally, they matched the names of prison inmates with names in the country's database of tuberculosis cases to determine the risk of contracting the disease while incarcerated.

Partnering with Brazilian officials

The researchers focused on the Brazilian state of Mato Grosso do Sul, near the border of Bolivia and Paraguay, which has one of the highest rates of incarceration in the country. The Brazilian Ministry of Health and the prison administration were eager to learn about the prevalence of tuberculosis in the incarcerated population and how best to combat the spread.

"It was a pretty incredible experience," said Tarub Mabud, MD, a resident in interventional radiology at New York University Langone Health. Mabud helped with the research as a medical student at Stanford. "We had to link the records of all current and previously incarcerated people in the state who had been diagnosed with tuberculosis between 2007 and 2013, as well as the dates of their incarceration and release."

Mabud doesn't speak Portuguese, which is the first language of most Brazilians. But with the help of government and public health officials, he was able to get the information he needed.

"Our hypothesis was that prisons were serving as hot spots for the amplification of tuberculosis, and that individuals could be spreading the disease after their release from prison," Mabud said. "So if we cut down on spread in the prisons, we could also lower the incidence of tuberculosis in the community. But we needed to know where to target our interventions."

Their findings shocked even Andrews, who has been studying infectious disease and public health since his residency at the University of California, San Francisco.

"At the time of incarceration, the prevalence of tuberculosis infection is very similar to that of the general population," Andrews said. "Less than

10% of people entering prisons have tuberculosis. But every year of incarceration is associated with a 25% to 40% increase in risk of infection, and by the time of their release, incarcerated people are 30 times more likely than those in surrounding communities to have tuberculosis."

The increase is likely due to the crowding of up to 40 people per cell and the sharing of beds by as many as three people, the researchers said. Ventilation is also often inadequate, and most prisoners spend nearly all day inside. Poor nutrition and widespread alcohol and drug use exacerbate disease spread. Finally, prisoners are frequently moved from one location in the prison to another, bringing them into contact with new, large groups of people.

"It's every bad condition you can think of," Andrews said. "And it's not unique to Brazil."

Comparing screening methods

Andrews and Mabud wanted to identify the most effective, cost-efficient way to screen prisoners and identify those who needed treatment. They ran computer models comparing the 10-year impact of five possible scenarios: screening each person for active tuberculosis as they begin their incarceration and treating those who are positive; screening them for active tuberculosis upon their release from prison and treating those who are infected; screening each person for latent tuberculosis upon entry into prison and providing preventive therapy to those who are infected; switching to a more sensitive diagnostic process to pick up more cases; or conducting mass screening of every incarcerated person for active tuberculosis and treating those who are positive.

The modeling suggested that entry screening was the least useful—likely because most disease spread is occurring inside the prison—and that exit

screening could be useful to stop newly released people from spreading tuberculosis to the community. "This is the opposite of the strategy recommended by the WHO," Andrews said. But the most effective intervention by far was mass screening of all incarcerated people.

"Mass screening is estimated to reduce the prevalence of tuberculosis in prisons by more than 40% in the prisons and by nearly 20% in the surrounding community," Andrews said. "For a single, targeted population, that is huge. As a comparison, the incidence of tuberculosis worldwide is declining by 1% to 2% per year."

A combination of the five interventions was projected to reduce the incidence of active tuberculosis in prisons by nearly 80% and in the community by 40%.

Mabud and Andrews published their [findings](#) in 2019 in *PLOS Medicine*. Two years before, Andrews received support from the National Institutes of Health to conduct a mass screening effort in the prisons to test the model's predictions. But it required an incredible on-the-ground effort from a panel of physicians, technicians, researchers and even the prisoners.

A large truck, donated by Brazilian police after they seized it from drug smugglers, was repurposed with lead lining, X-ray machines and rapid molecular diagnostic equipment. It traveled between three prisons in the area, screening every person regardless of symptoms.

"Ninety percent of incarcerated people want to be screened," Andrews said. "They are eager to know if they are infected. We found the prevalence of tuberculosis in prisons to be around 4,000 per 100,000 people. In comparison, only about 35 of 100,000 people in the general population are infected. It's an astronomical increase. In our first year, we identified two and a half times as many cases in the prisons

compared with the previous year, before mass screening was implemented. Clearly, the passive detection methods the prisons have been using are not doing a sufficient job of finding cases. It's important to catch people early before they become symptomatic and infectious."

Once infected people were diagnosed, however, outcomes were usually good—possibly because it is relatively easy to monitor medication adherence in prisons over the six-month course of treatment.

They published their [results](#) in March of 2021 in *Clinical Infectious Diseases*. Between 2017 and 2018, the researchers screened more than 5,000 people from three prisons in the state by asking whether they were experiencing any tuberculosis symptoms, performing a chest X-ray, and collecting sputum for a molecular diagnostic assay and for direct culture in the laboratory. Of those screened, 3.9% were diagnosed with tuberculosis. The team found that the molecular diagnostic test performed on sputum detected 74% of all cases at a total cost of about \$250 per positive result, making it efficient and cost-effective.

New diagnostics to tackle an ancient disease

Since that time, the team has screened more than 15,000 people and begun testing new diagnostic tools, including novel blood tests and tests to detect tuberculosis in breath. They've also enlisted the aid of prisoners to collect swabs from surfaces for a pilot project to learn if it is possible to detect the tuberculosis bacteria that way.

"It's clear that we've underestimated the role of prisons in driving the tuberculous epidemic," Walter said. "Our studies demonstrate the growing health and human rights crisis created by incarceration. Tuberculosis is an ancient disease, and we have the tools to diagnose and treat it. But hidden and vulnerable populations are at high risk."

Another study [published](#) in March of 2021 and headed by postdoctoral scholar and genomic epidemiologist Katharine Walter, Ph.D., traced the spread of specific tuberculous strains in members of the community, international travelers and incarcerated people by the genomic sequence of the tuberculous bacteria.

"Each prison block houses several hundred people, and the [prison](#) administrators weren't about to let a couple of foreign medical students wander in the facility," Mabud said. "But each block had a leader who interfaces with the administration and is well-respected by their block mates. These leaders were excited to help with the research and would even give us advice about the best places to get samples. We'd give them as much instruction as possible, explaining how to avoid contaminating the swabs, and what we were looking for."

Andrews agrees. "This effort has been particularly fulfilling," he said. "We're having a direct impact via screening and treatment, and we're seeing good science translated into important policy changes at a national level."

The work the research team has done on TB in Brazil may also have a direct impact on the spread of COVID-19 in prisons closer to home.

"We've seen this in incarcerated populations in the United States, where the incidence of COVID-19 is three to five times higher than in the general population," Andrews said. "Early in 2020, we saw large, explosive outbreaks with really high attack rates, and in some cases 70% to 90% of the incarcerated population became infected. There are two important points here—what we can learn from other diseases when we try to control COVID, and what we can learn from fighting COVID that can help our understanding of the spread of other respiratory diseases like [tuberculosis](#)."

Provided by Stanford University Medical Center

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