TB, Silicosis and HIV
Architectural and Engineering Approaches to Airborne Infection Control
Winter Course 6 July 2015

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Silicosis: An inflammatory condition: particles of silica dust are inhaled, macrophages ingest the dust particles and set off an inflammation response which leads to fibrosis or progressive scarring of the lungs.

Tuberculosis: A bacterial infectious disease transmitted though coughing.

HIV: a viral, mainly sexually transmitted, disease.

Silicosis increases the risk of TB by about 3 times. HIV increases the risk of TB by 5 to 10 times.
Before Europeans colonized southern Africa

- There were no hard-rock mines so no silicosis
- There was no tuberculosis
- HIV did not exist.

All diseases of colonization and industrialization in the 19th and 20th century
Countries of the world ordered by TB incidence

TB incidence/100k/year

Swaziland
South Africa
Namibia
Zimbabwe
Sierra Leone
Lesotho
Djibouti
Botswana
Mozambique

TB in the world
HIV in the world

Countries of the world ordered by HIV prevalence

HIV prevalence in adults (%)

Swaziland
Botswana
Lesotho
South Africa
Zimbabwe
Namibia
Mozambique
Malawi
Uganda
Kenya
Tanzania
Where did it all begin?
William Gorgas, Surgeon General, US Army

1910: Controlled yellow fever and malaria in Panama by draining swamps, fumigation, mosquito netting and clean water.

1913: Report for the Transvaal Chamber of Mines
“The crowded and unsanitary living conditions combined with the stressful working conditions lead to very high rates not only of silicosis and tuberculosis but also of pneumonia.”
Tuberculosis on the mines in the 1920s

Annual incidence of TB ~1,800 per 100,000 miners

Approximately 1,000 miners with TB disease were being repatriated every year to rural areas of southern Africa.
Leon Commission of Enquiry into Health and Safety on the Mines: 1996

Men working underground for 20 years have a 20% to 30% chance of developing silicosis.

“There is no evidence to indicate a decline in the prevalence or severity of any occupational disease in the mining industry during the past twenty years ... radical steps are required to deal with the serious occupational health problems described in the evidence presented to the Commission.”
Start with HIV
Impact of ART on HIV and TB in Brazil

ART reduced mortality in AIDS cases by 96% and TB incidence by 88%
Viral load suppression

Good news: 10,000x reduction after 1 year
Bad news: No elimination of the virus

Palmer 2008 Proceedings of the National Academy of Science
Reducing viral load to 100/mL reduces transmission by 99%
Stopping the epidemic with ART

No intervention
ART CD4 < 350/μL
Immediate ART

Incidence
Prevalence
Mortality
Drug resistance: Vancouver

Reducing community viral load drives acquired resistance down

Gill 2010 Clinical Infectious Diseases
Cost of universal ART as a percentage of GDP

Cumulative cost of universal ART
What does this do to TB?
HIV drives TB

Delay ~ 5 years

Kisumu, Kenya

IRR ~ 15

HIV prevalence (%)

TB notifications per 100,000 people per year

Year

Gold Miners in South Africa

HIV- | HIV+
---|---
1991-1994: 1.0 | 2.2
1995-1997: 1.1 | 5.9
1998-1999: 1.1 | 9.4

IRR ~ 10
IRR ~ 2

Corbett et al. Journal of Infectious Diseases 2003; 188: 1156-63
TB in HIV positive people does not affect HIV-negative people.

Prevalence = Incidence x Duration

HIV-positive people with TB progress about 10 times faster than HIV negative people.

If CD4 falls by 100/μL, TB increases by 38% (25%–53%).

$I \propto e^{-0.0038C}$

During the acute phase of HIV:
CD4 cell counts drop by 25% (9%–41%)\(^1\)
TB incidence rises 3.8 (1.6–15.2) times.\(^2\)

Impact depends on the setting

Zimbabwe

TB incidence/100k/yr

HIV prevalence

IRR ~ 34

Botswana

TB incidence/100k/yr

HIV prevalence

IRR ~ 7.4


Impact depends on the setting
Impact depends on the setting

Zimbabwe

Botswana

TB incidence/100k/yr

IRR ~ 34

IRR ~ 7.4


Tuberculosis

Impact depends on the setting

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IRR ~ 34

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TB in South Africa: Test and treat
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HIV positive; not ART
TB in South Africa: Test and treat

HIV positive; all
January 28, 2007

Virulent TB in South Africa May Imperil Millions

By MICHAEL WINES

JOHANNESBURG, Jan. 27 — More than a year after a virulent strain of tuberculosis killed 52 of 53 infected patients in a rural South African hospital, experts here and abroad say the disease has most likely spread to neighboring countries, and some say urgent action is essential to halt its advance.
Emergence of XDR-TB in Tugela Ferry

Extensively drug-resistant tuberculosis as a cause of death in patients co-infected with tuberculosis and HIV in a rural area of South Africa

In 2005 there was an outbreak of XDR TB at COSH. 52 of 53 patients with XDR tuberculosis died, with median survival of 16 days from time of diagnosis.

<table>
<thead>
<tr>
<th>Year</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cases</td>
<td>5</td>
<td>140</td>
<td>97</td>
<td>133</td>
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</table>
XDR TB in Districts of KwaZulu-Natal 2006
XDR TB in hospitals in uMzinyathi 2006
The outbreak in Tugela Ferry was a failure of infection control
TB cure rates

WHO says that at least 85% of all TB patients should be cured. Out of 40 countries in sub-Saharan Africa our cure rate of 79% puts us in 25th place. A good place to start would be to make sure that we can cure the patients that we already have.
What about silicosis?
Prevalence of Silicosis in ex-Mine Workers

White in Botswana 30%
Trapido in Libode 28%
Churchyard in Free State 21%

The mining industry owes ex-miners living in rural areas approximately R3 billion in unpaid compensation
Any person who works or who has worked at a mine or works, or any other person acting on behalf of such a person, may at any time apply to the Director for a medical examination of such a person for the purpose of determining whether such a person is suffering from a compensatable disease....The Director of the Medical Bureau for Occupational Disease is obliged to cause such a person to be medically examined as soon as possible.... ex-mineworkers are entitled to a bi-annual benefit examination and to transport costs on an annual basis.
The way forward: HIV

- People at risk of HIV must be tested at least once a year and started on ART as soon as they become infected.
- Mobilize community support to ensure high rates of uptake and compliance.
- Find a way to provide drugs and support to a very mobile population especially migrant workers.
- Smart cards for providing drugs and monitoring patients? Regional network of clinics?
The way forward: TB

- Universal access to ART will take care of about half of the TB problem.
- Cure the patients we already have.
- Life-time follow up of all TB patients.
- Good infection control. Ventilation? UV lights?
- Smart cards for providing drugs and monitoring patients?
The way forward: silicosis

• Ensure that all ex-miners receive the compensation to which they are entitled under law.
• Find ways to limit exposure to silica dust.
• If necessary plan a future which does not depend on gold.