Impact of TB transmission in prisons to the community

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Brazil's TB Research Network
(Rede-TB)

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GrupodeTuberculose

LPCS
Laboratório de Pesquisa
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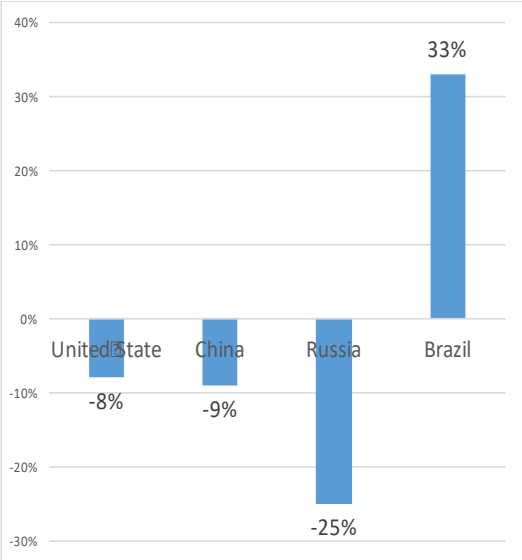
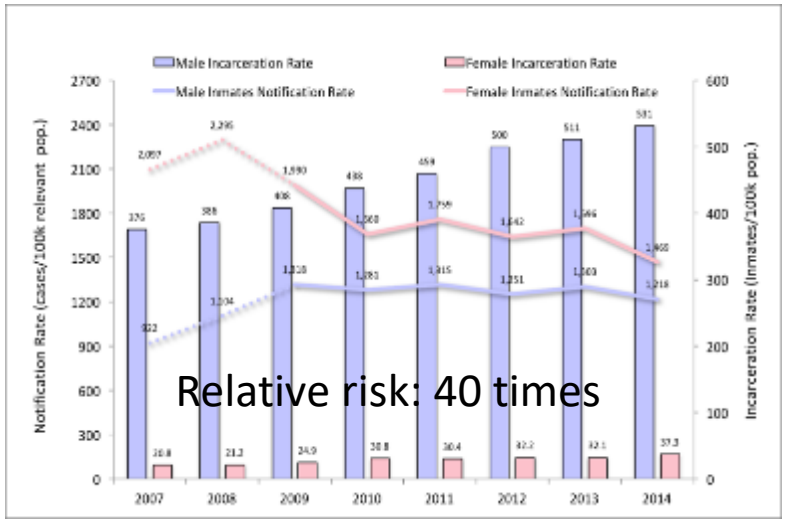
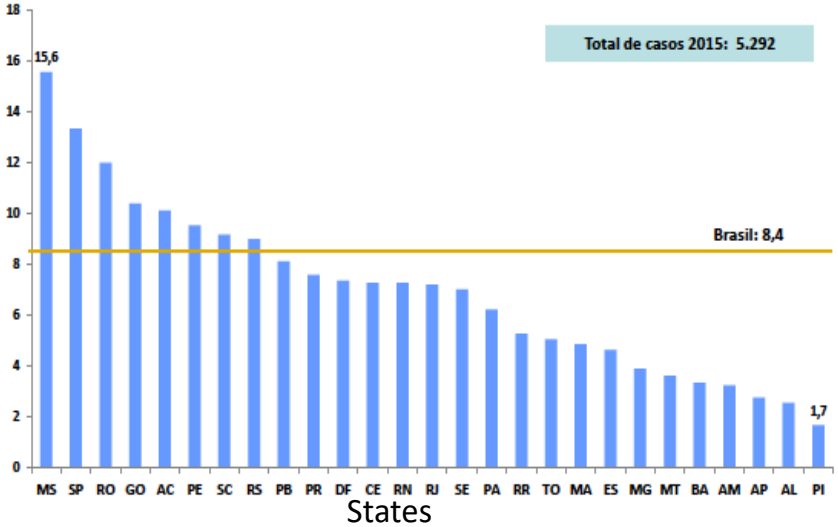
Brazilian Prisoners

- **4th largest prisoner population**
  - 574,270 prisoners
  - 33% increase of prison population between 2008 and 2014
  - Incarcerate rate 275 per 100,000
  - 66% above prison capacity
- **TB in Prison:**
  - US (6.3/100,000)
  - Africa (>2,000/100,000)
  - Brazil (1,300/100,000)
    - ✓ 8% of all reported TB cases
    - ✓ Doubled since 2007

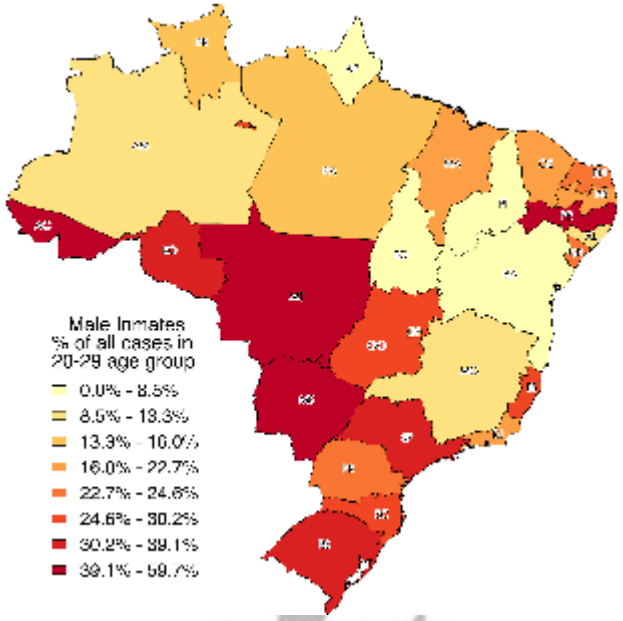






TB Epidemic in Mato Grosso do Sul Prisoners

- Established sentinel site for MoH in Mato Grosso do Sul:
  - Highest incarceration rate
  - low HIV setting
  - Highest proportion of prisoners among new TB cases
  - High burden among young men



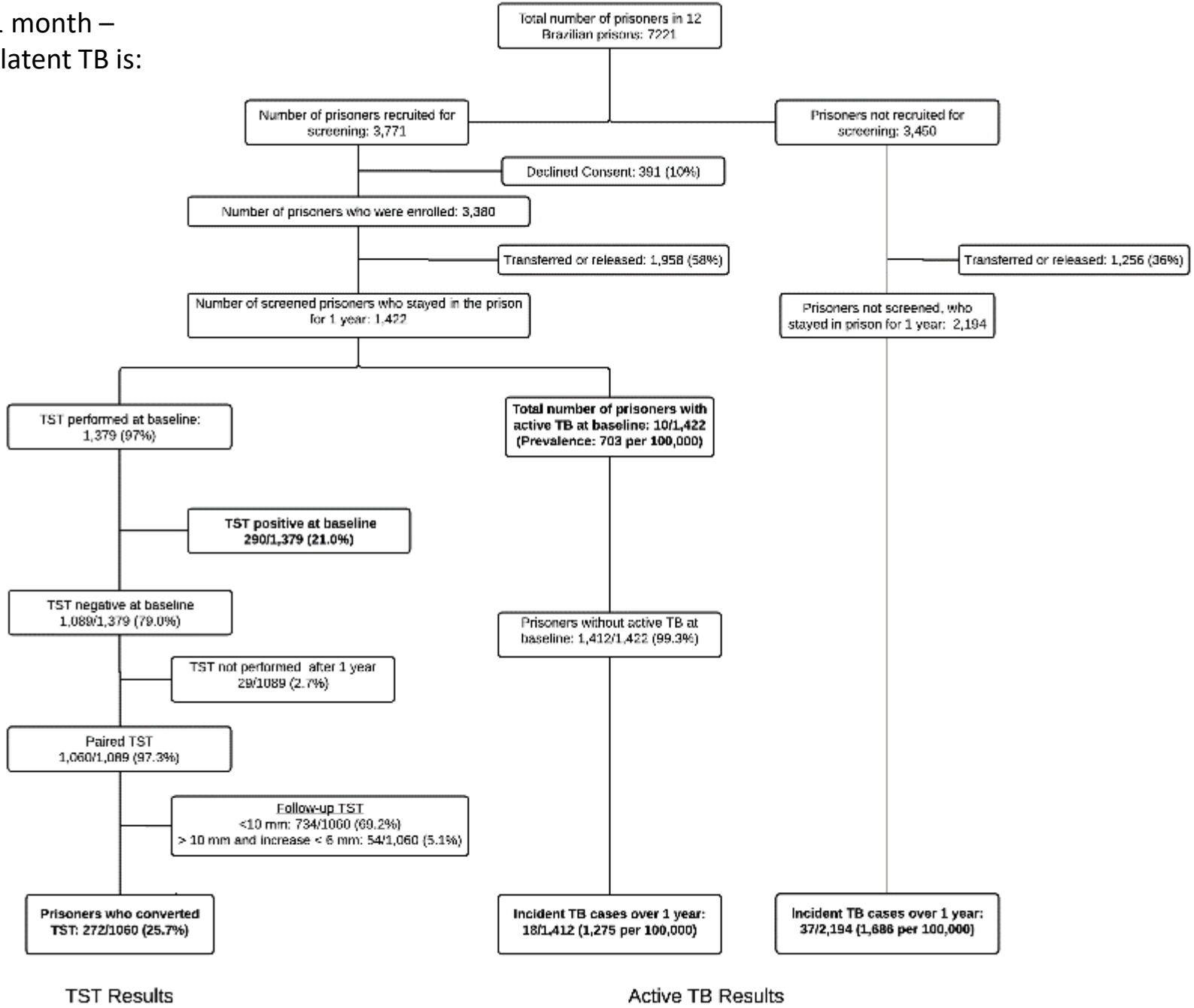
- Cohort study started in 2013
  - 12 prisons in MS
    - (8 male and 4 female)
  - Proporcional stratified sample
  - Caso definition:
    - LTBI: induration ≥ 10 mm in TST
    - LTBI in HIV: ≥ 5 mm in TST
    - Active TB: smear and /or positive culture

Bourdillon et al. Accepted. EID 2016
Carbone et al. *BMC Infectious Diseases* 2015

Prison time ≤1 month –
Prevalence of latent TB is:

7.9% in men

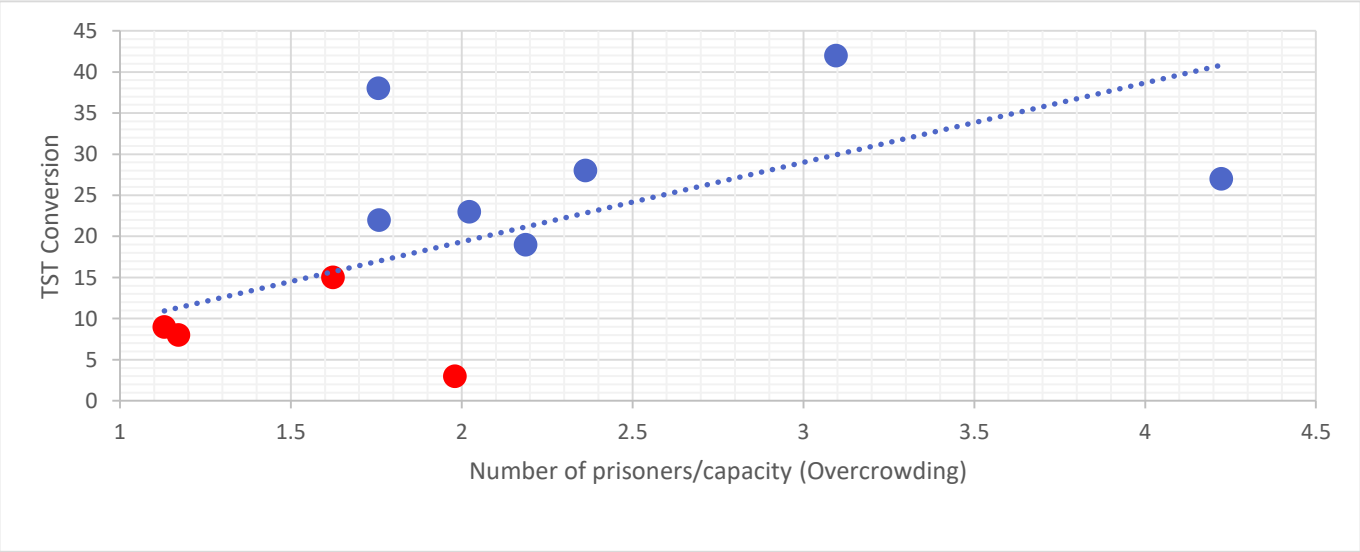
8.3% women



Carbone et al. *BMC Infectious Diseases* 201
Paião et al. *BMC Infectious Diseases* 2016

Tuberculin skin test (TST) conversions and tuberculosis (TB) incidence in 8 male and 4 female Brazilian prisons (N=1,422)

Variables	Prisons		
	Male	**Female**	**Total**
Capacity	2,469	451	2,920
Inmate population	6,552	669	7,221
Individuals enrolled at baseline	2,861	519	3,380
Individuals followed for 1 year	1,235	187	1,422
TST-negative subjects	905	155	1,060
TST converted subjects	256	16	272
TST conversion rate, %[a]	**28 (25-32)**	**10 (6-17)**	**26 (23-29)**



Paiao et al. *BMC Infectious Diseases* 2016

The Impact of Ventilation and Early Diagnosis on Tuberculosis Transmission in Brazilian Prisons.

Structural Environment of Prisons and Tuberculosis

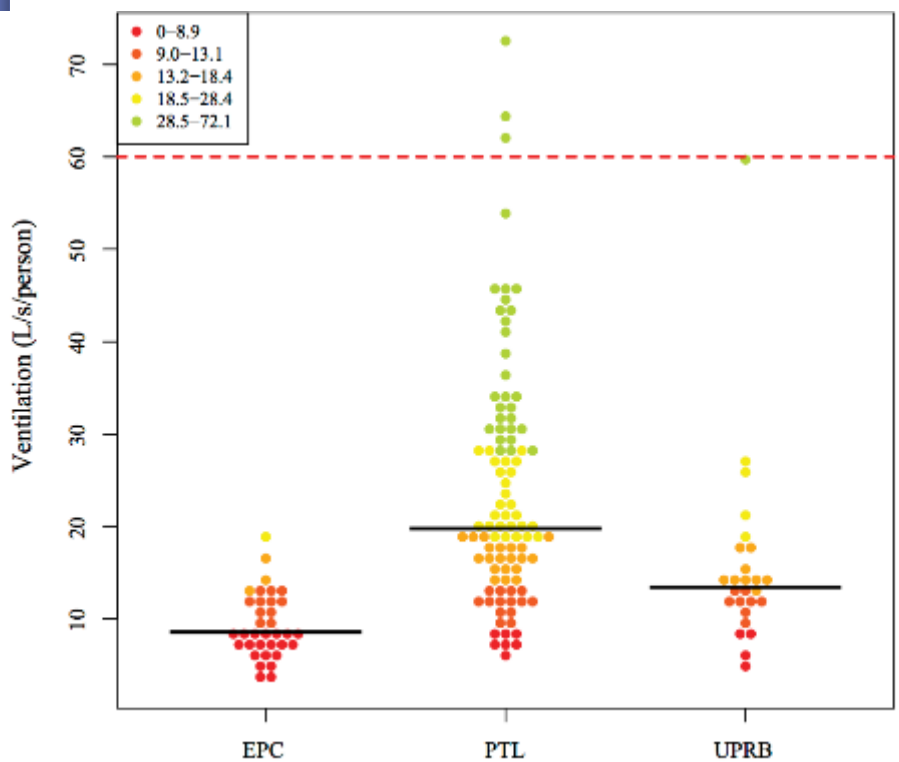
- Perfect storm of largely susceptible population (<10% LTBI) coming into a high transmission setting
- Performed detailed assessment of architectural design, crowding, and ventilation in 3 prisons
- Obtained steady-state carbon dioxide measurements in each cell to estimate ventilation
- Projected tuberculosis risk over time
- Modeled interventions

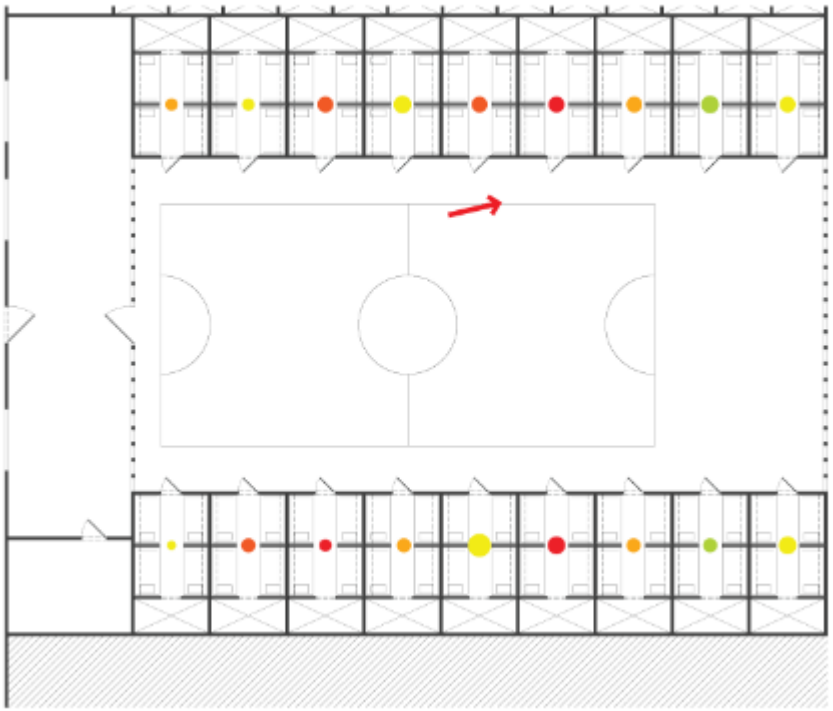
Table 1. Description of the sample, by prison (N=141 cells)[a]

Cell Characteristic[b]	EPC (n=32)	PTL (n=85)	UPRB (n=24)	*p*-value[c]
Individuals per cell	**13.2 ± 5.9**	**5.8 ± 2.7**	**11.7 ± 6.0**	<0.001
Beds per cell	6.4 ± 4.1	2.9 ± 1.5	5.7 ± 1.7	<0.001
Absolute ventilation (L/s)	119.1 ± 54.0	128.7 ± 74.4	202.3 ± 217.5	0.008
Air changes per hour (ACH)	12.6 ± 4.6	15.0 ± 12.5	21.8 ± 26.7	0.066
Steady-state CO_2 (ppm)	989 ± 204	652 ± 159	775 ± 158	<0.001
Floor area (m^2)	13.1 ± 6.9	13.3 ± 4.7	13.0 ± 3.6	0.959
Ceiling height (m)	2.9 ± 0.2	3.2 ± 0.2	2.9 ± 0.2	<0.001
Opening area (m^2)[d]	4.3 ± 0.8	2.8 ± 0.3	5.1 ± 3.9	<0.001
Openings facing prevailing winds, n (%)[e]	14 (43.8)	40 (50.0)	8 (33.3)	0.346
Interior concrete walls	2.5 ± 1.1	2.3 ± 1.0	2.0 ± 0.5	0.144
Portable fans	7.5 ± 8.0	2.6 ± 1.5	5.7 ± 2.8	<0.001
Cells per courtyard	3.8 ± 1.4	19.4 ± 6.1	4.6 ± 1.7	<0.001
Courtyard area (m^2)	55.0 ± 17.1	316.3 ± 94.7	54.0 ± 15.9	<0.001
Recreational time (hrs)	7.2 ± 4.5	4.0 ± 2.4	9.3 ± 1.0	<0.001

Urrego J, *et al, AJTMH 2015*

Ventilation by Cell

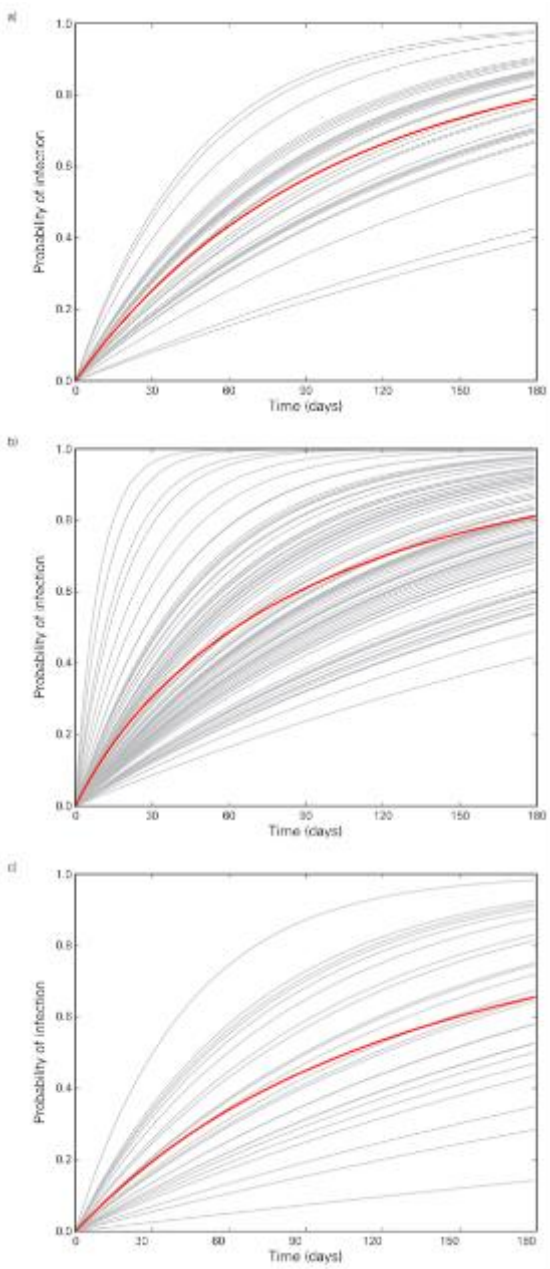


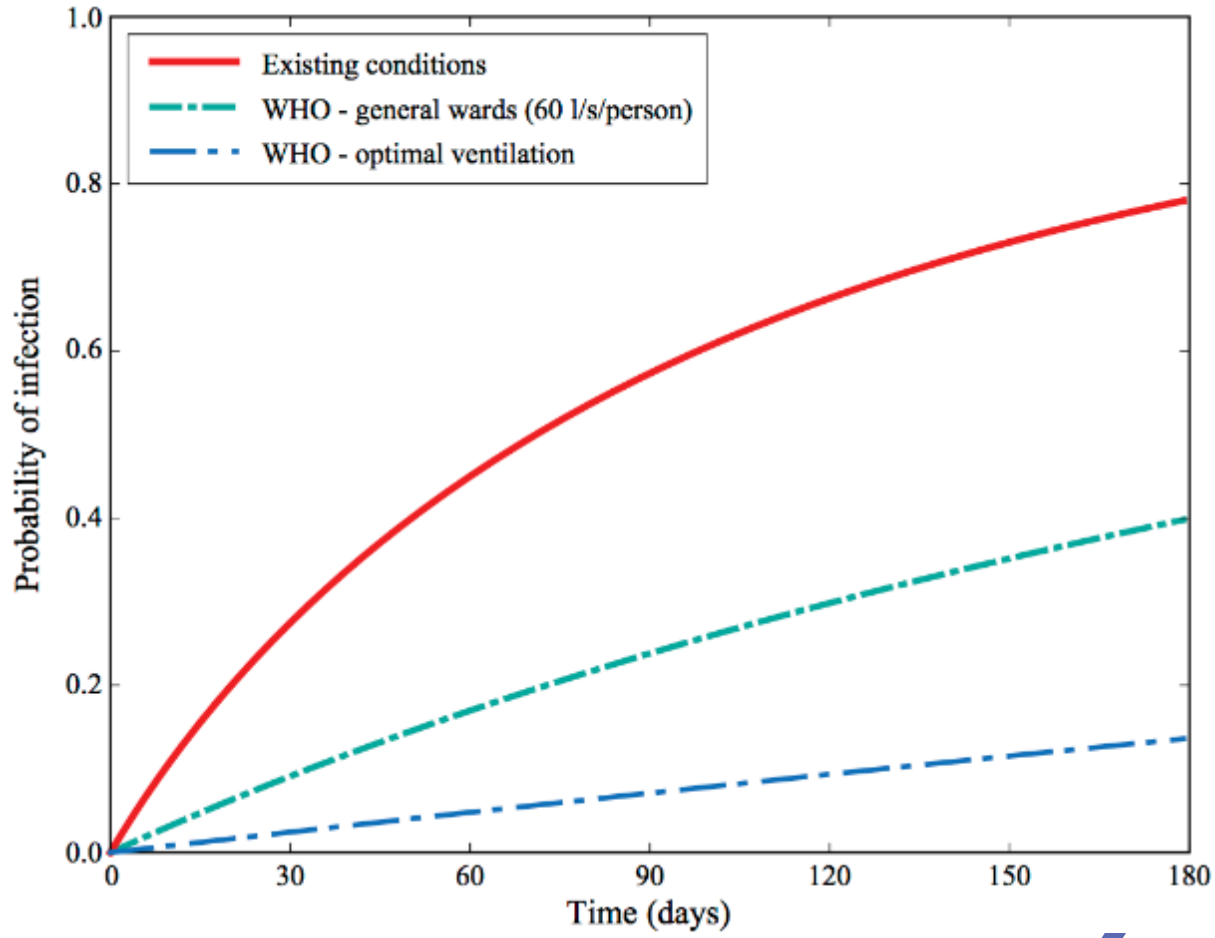


- Each cell has 1.6 m2 per prisoner
- 98% of the cells have worse ventilation than is recommended by WHO
- Prisoners remain in the cells for 16 to 20 hours

Urrego J, *et al, AJTMH* 2015

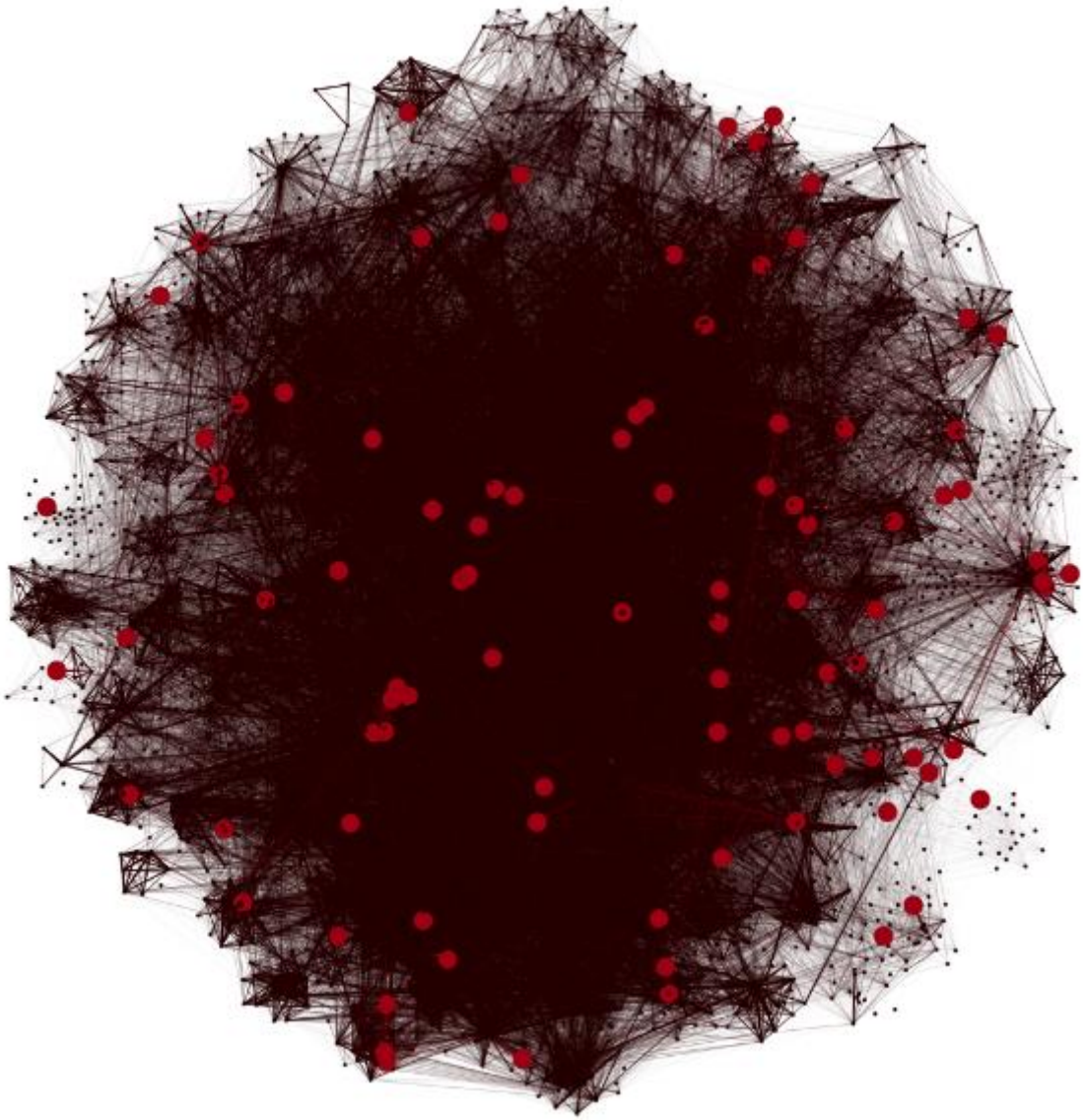
Impact of ventilation





Urrego et al. *AJTMH* 2015

Social Network of Prisoners



Milinda, *et al. In Preparation*

Impact of reducing diagnosis time

- 53-70% of prisoners are infected after exposure to a case of TB for 4 months (average between onset of symptoms and diagnosis in these prisons)
- Due to mobility, each case of TB has contact (2 weeks) with 37 to 45 inmates in a period of 4 months
- Early dx averts only 8% infections

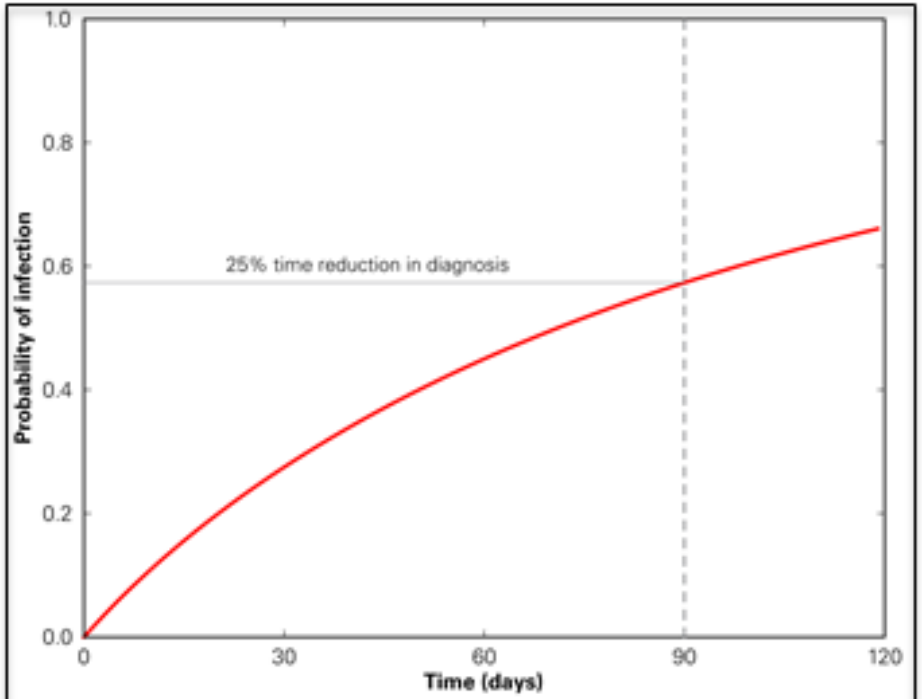
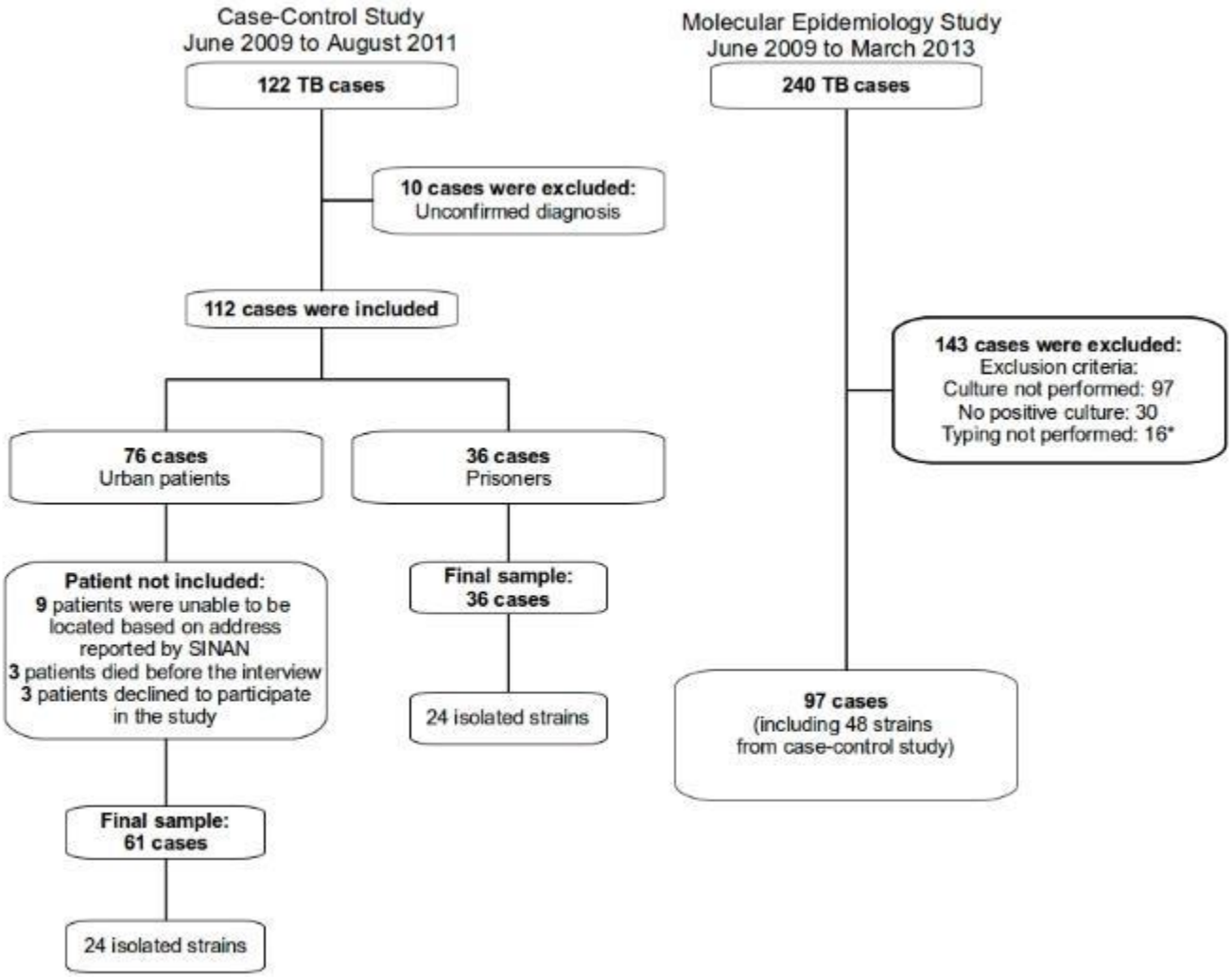


Figure 6. Projected probability of infection in average prison cell over time of exposure to an infectious case, and impact of reducing diagnosis time by 25% (dotted line).

Urrego et al. *AJTMH* 2015

Prisons as reservoir for community transmission of tuberculosis, Brazil.

Recrutiment of cases



*11 strains could not be reactive after freezing and 5 strains had less than 5 bands of IS6110.

Sacchi F. et al. *EID* 2015

Results

Table. Risk factors for TB in community and prison populations, Dourados, Brazil, June 2009–August 2011*

	Community, n = 183, no. asked/no.responded (%)				Prison, n = 108, no. asked/no. responded (%)		
Variable	TB cases, n = 61	Controls, n = 122	Crude OR (95% CI)	Adjusted OR (95% CI)	TB cases, n = 36	Controls, n = 72	Crude OR (95% CI)
Male sex	41/61 (67)	42/122 (34)	3.9 (2.0–7.5)	6.6 (2.4–18.1)	NA	NA	NA
[illegible]†	19/61 (31)	22/122 (18)	2.1 (1.0–4.2)	3.4 (1.1–10.6)	NA	NA	NA
No primary school	15/61 (25)	25/122 (21)	1.3 (0.6–2.6)	NA	11/36 (31)	14/72 (19)	1.82 (0.73–4.57)
Smoked	20/61 (33)	24/122 (20)	2.0 (1.0–4.0)	NA	17/36 (47)	36/72 (50)	0.89 (0.40–1.99)
Alcohol use	14/61 (23)	7/122 (6)	4.9 (1.9–12.9)	11.5 (2.0–67.0)	6/36 (17)	12/72 (17)	1.00 (0.34–2.93)
Drug use	15/61 (25)	2/122 (2)	19.6 (4.3–88.9)	NA	26/36 (72)	48/72 (67)	1.30 (0.54–3.13)
Diabetes	7/61 (12)	13/122 (11)	1.1 (0.4–2.9)	NA	1/36 (3)	1/72 (1)	2.03 (0.12–33.40)
Contact with person with TB	18/61 (30)	15/122 (12)	3.0 (1.4–6.5)	5.6 (1.4–22.0)	23/36 (64)	54/72 (75)	0.59 (0.25–1.40)
Mycobacterium bovis BCG vaccine scar	41/61 (67)	96/122 (79)	0.6 (0.3–1.1)	NA	28/36 (78)	54/72 (75)	1.17 (0.45–3.02)
Prior incarceration	14/61 (23)	1/122 (0.8)	36.0 (4.6–281.8)	24.5 (2.4–254.6)	NA	NA	NA

*TB, tuberculosis; OR, odds ratio; NA, not applicable; BCG, Bacillus Calmette-Guérin.
†Monthly individual income in US dollars.

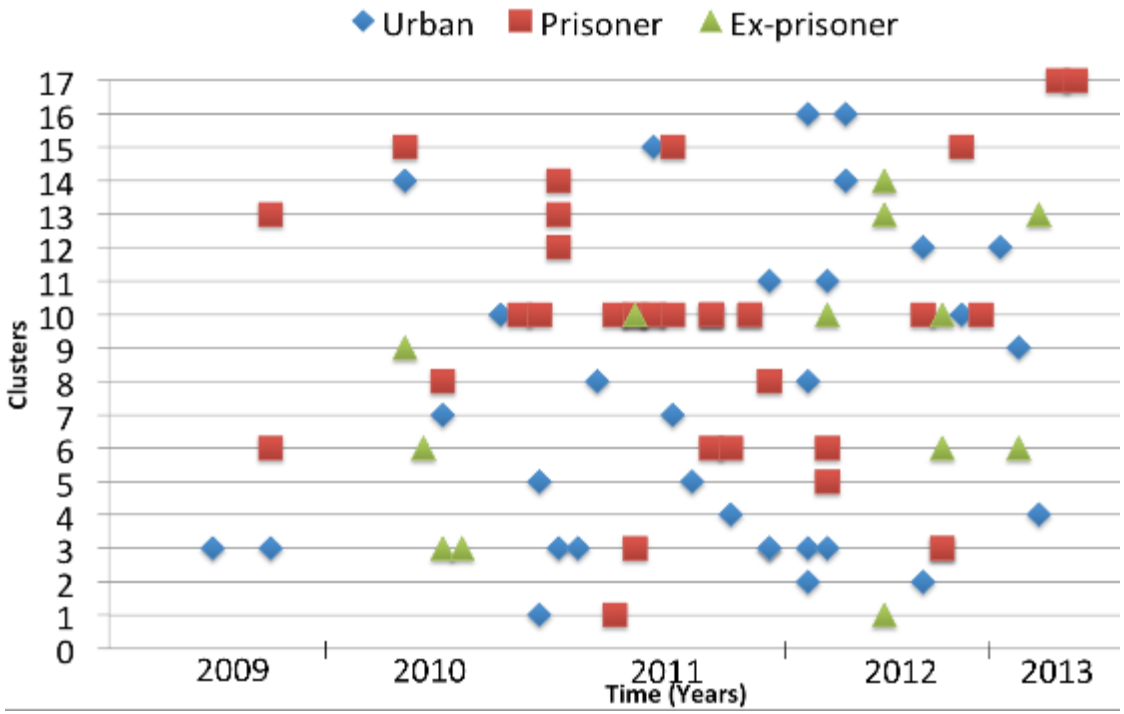
Among 180 cases over 2 years, 25% occurred among incarcerated individuals
In remaining, non-incarcerated population, 23% were among ex-prisoners

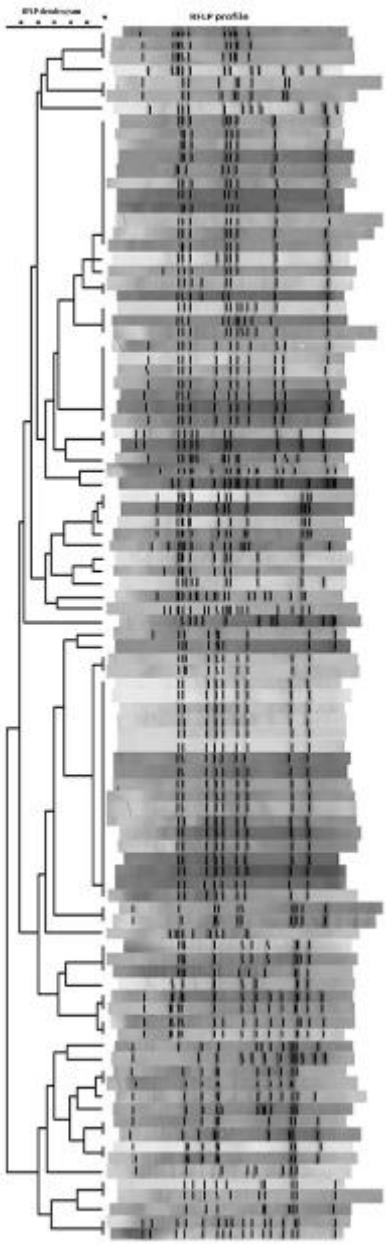
Sacchi F. et al. *EID* 2015

Molecular Evidence of Spillover

- Performed IS6110-RFLP on 97 isolates

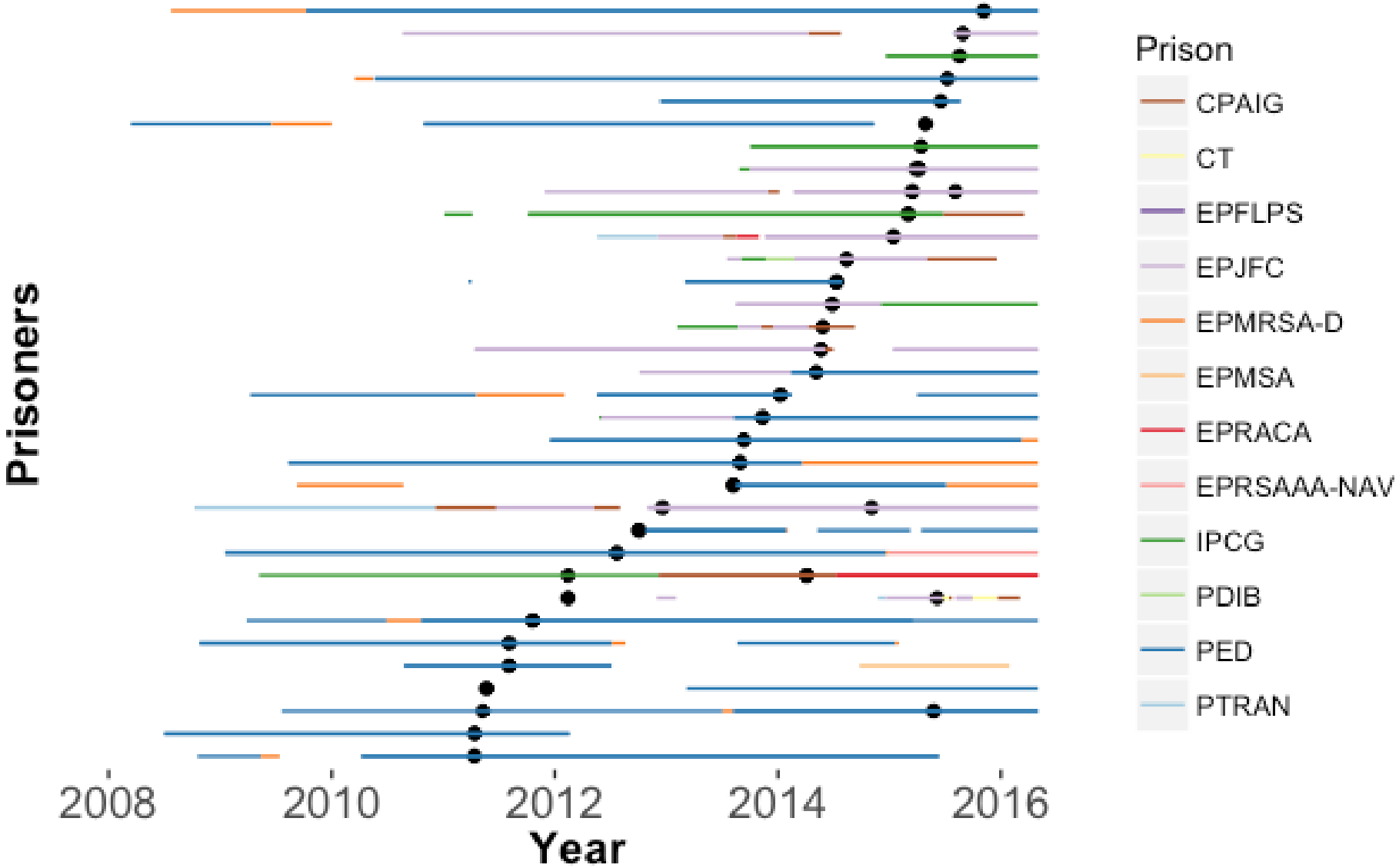
- Of 59 cases in general pop., 32 (54%) shared genotype with strains isolated among prisoners; majority (20; 63%) had no history of incarceration





Sacchi F, *et al. EID 2015*

Cluster 10 (27 prisioners)



One RFLP type seen in 12 prisons over five years in Mato Grosso do Sul

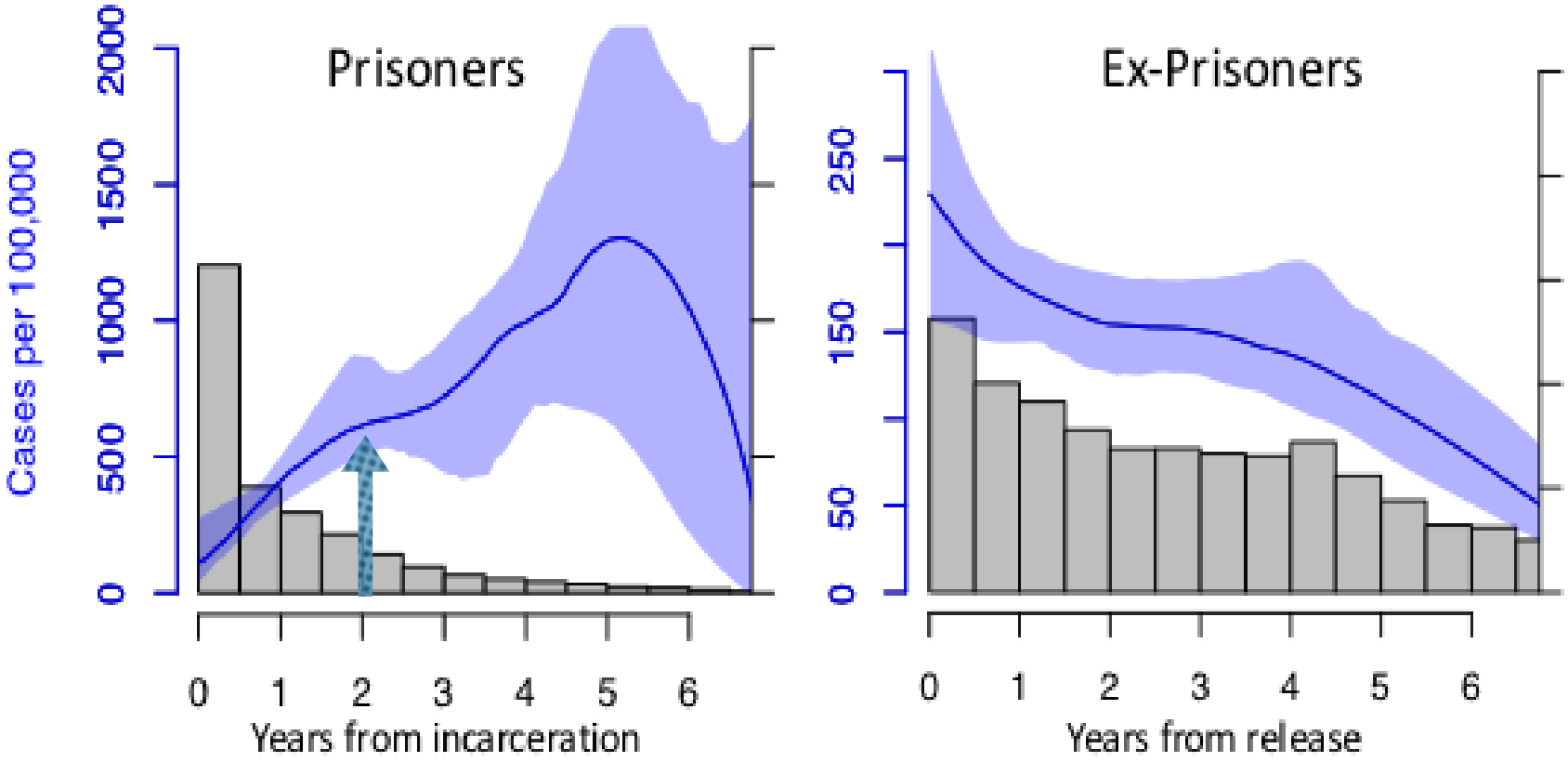
Unpublished data

Measuring TB incidence among prisoners and ex-prisoners

- Obtained all incarceration and release data from 2007-2015 (AGEPEN; N=42,925)
- Used fuzzy matching algorithm to match inmates or ex-prisoners with TB cases from SINAN
- Individually verified matches by name, mother's name, date of birth
- Calculated TB incidence and hazards from time of incarceration and release

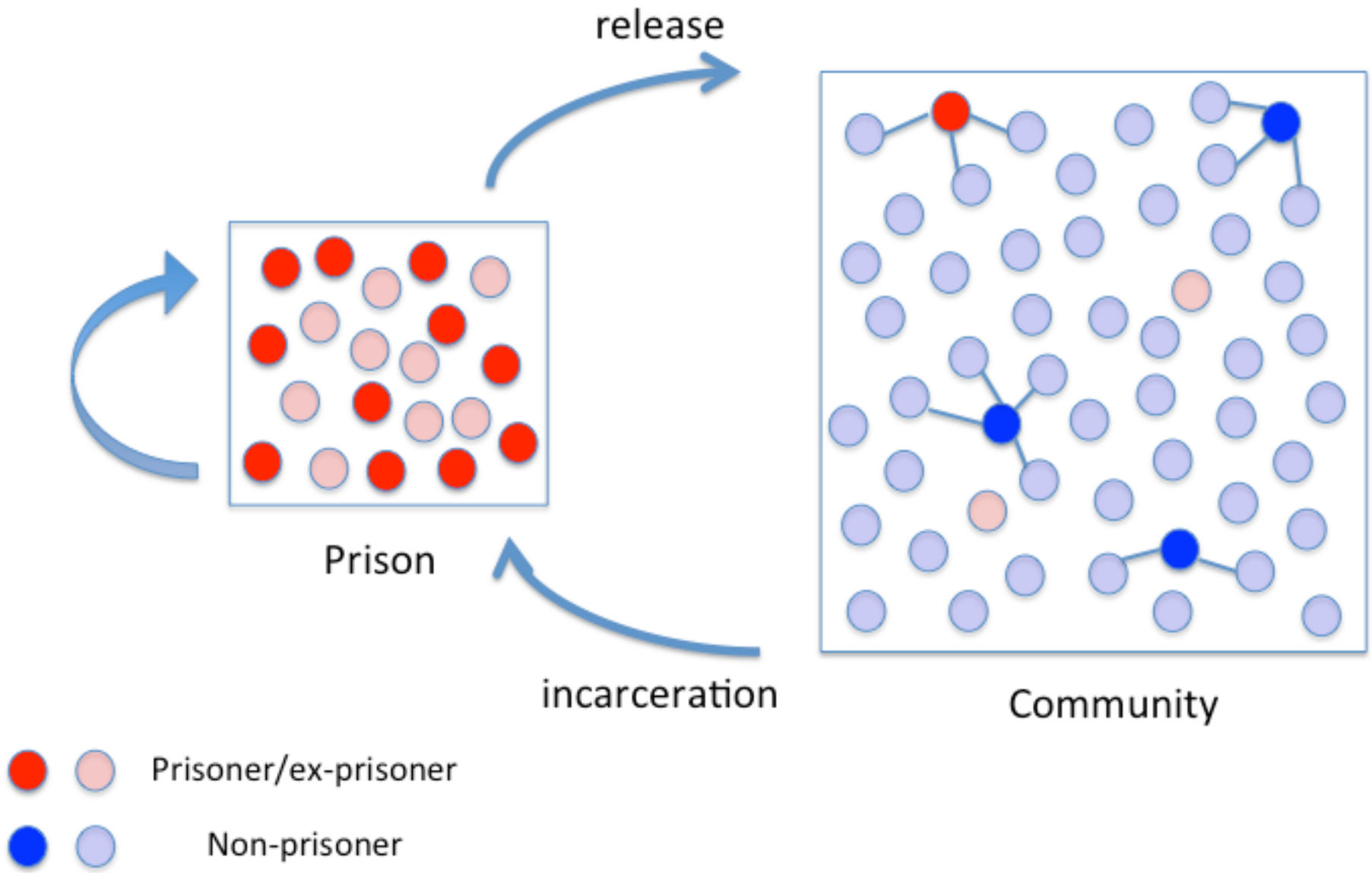
Mabud T, *et al. In Preparation*

Timing of TB among prisoners

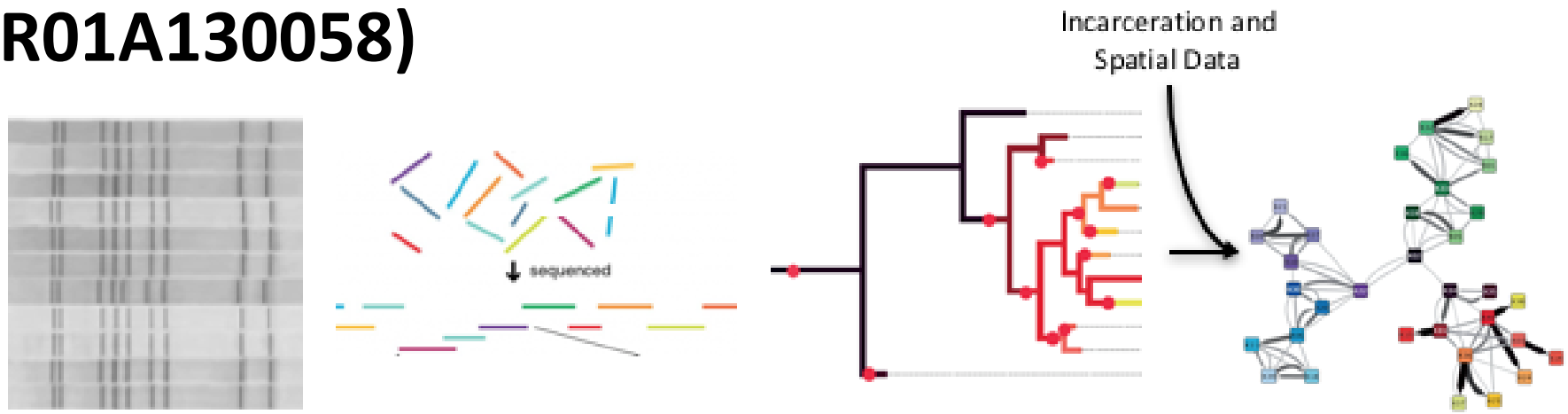


Mabud T, *et al. In Preparation*

Prisons as “institutional amplifiers” for TB



Next steps: Bayesian inference of transmission incorporating WGS, incarceration and spatial data **(R01A130058)**



1. Cluster identification by RFLP

2. Whole genome sequencing of clusters

3. Generation of phylogenetic trees

4. Generation of transmission trees

Table 2. Description of isolates already available from study sites.

	Dourados (2009-2015)	Campo Grande (2014-2015)	Total
Pulmonary TB cases	282	294	576
Isolates available	199 (71%)	246 (84%)	445 (79%)#
Prisoners	86 (43%)	124 (50%)	210 (47%)
Ex-prisoners	27 (14%)	12 (5%)	39 (9%)
Non-prisoners	86 (43%)	110 (45%)	196 (44%)
RFLP performed	195 (98%)	124 (50%)*	319 (72%)
Clustered isolates	138 (73%)	94 (76%)	243 (76%)

Isolates available for **92%** of culture-confirmed cases (most unavailable isolates are culture-negative cases)
*RFLP on prisoner cases completed; community cases underway.

- New Bayesian inferential approach moving from phylogenetic (3) to transmission trees (4)
- Weighted to probability of directional transmission

Yale, Columbia and Stanford: Cohen, Mathema, Colijn and Andrews

How do we get people to care about prisoners?

HARD LABOR AND TUBERCULOSIS.

To sentence a prisoner to "hard labor and tuberculosis" would shock the moral sense of the community, even more than a reversion to the infliction of the penalty of prompt and merciful death for offenses not now deemed capital. However, the moral sense referred to may well be shocked by the announcement from Albany, made on the authority of Dr. J. B. RANSOM, physician of the Clinton State Prison at Dannemora, that one-quarter of the population of that institution are afflicted with tuberculosis. Out of 250 prisoners thus diseased 54 are properly cared for, and provision is now making for the partial isolation of 100 more, leaving in round numbers a hundred to mingle with the other prisoners and spread the infection.

Whether criminals have any rights which society is bound to respect may be considered debatable. But this question does not seem to arise as clearly, in the case of prison officials, who render a necessary if disagreeable and not distinguished service to the State, as in the case of prisoners. Dr. RANSOM does not think the matter is "quite understood." Probably he is right—especially as to the fact that from 90 to 100 tuberculous patients are being discharged from Dannemora every year, by expiry of sentence, without any precautions against their agency in spreading the infection wherever they go. If the prisoners are not properly the objects of sympathy, perhaps the people outside the prisons may be so considered.

New York Times, 1903

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