TUBERCULOSIS IN THE ARTISANAL MINING OF THE DEMOCRATIC REPUBLIC OF CONGO: A SILENT KILLER

PATRICK DE MARIE KATOTO, MD, MSC, PhD

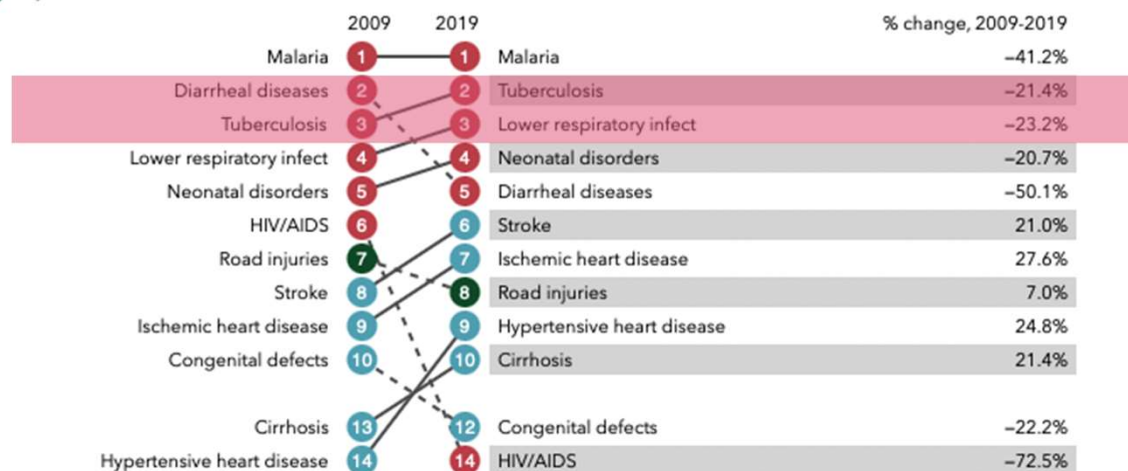CATHOLIC UNIVERSITY OF BUKAVU

ANVERS, 10-11-2022

PLAN

1. CAUSES OF DEATH IN THE DRC

2. STATE OF AIR POLLUTION IN THE DRC

3. IMPACT OF MINING ACTIVITIES ON THE EPIDEMIOLGY OF TUBERCULOSIS IN THE DRC

4. THE NEED FOR A STRONG NETWORK TO LIMIT THE IMPACT OF TB IN THE DRC MINING

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What causes the most deaths?

- ● Communicable, maternal, neonatal, and nutritional diseases
- ● Non-communicable diseases
- ● Injuries

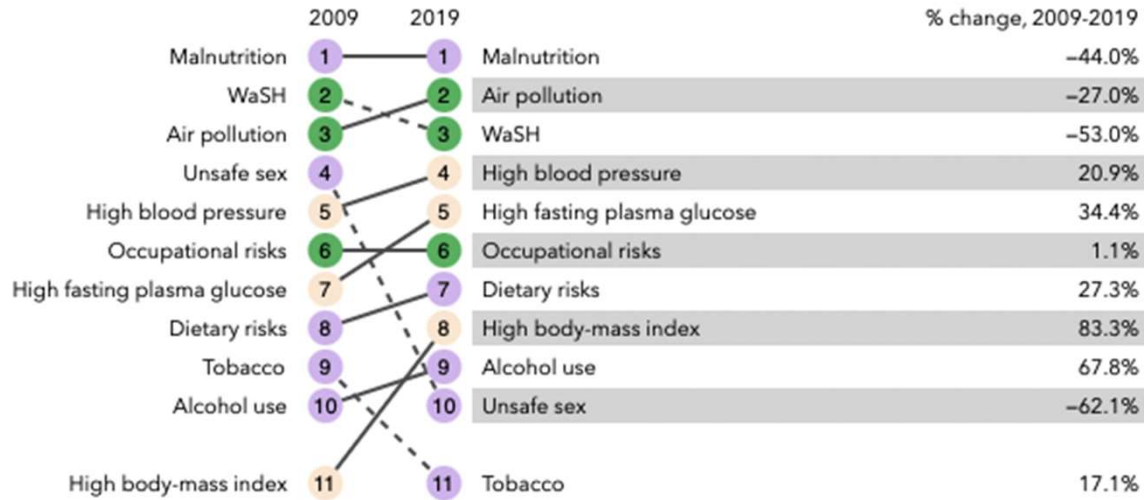|	2009	2019		% change, 2009-2019
Malaria	1	1	Malaria	−41.2%
Diarrheal diseases	2	2	Tuberculosis	−21.4%
Tuberculosis	3	3	Lower respiratory infect	−23.2%
Lower respiratory infect	4	4	Neonatal disorders	−20.7%
Neonatal disorders	5	5	Diarrheal diseases	−50.1%
HIV/AIDS	6	6	Stroke	21.0%
Road injuries	7	7	Ischemic heart disease	27.6%
Stroke	8	8	Road injuries	7.0%
Ischemic heart disease	9	9	Hypertensive heart disease	24.8%
Congenital defects	10	10	Cirrhosis	21.4%
Cirrhosis	13	12	Congenital defects	−22.2%
Hypertensive heart disease	14	14	HIV/AIDS	−72.5%

Top 10 causes of total number of deaths in 2019 and percent change 2009-2019, all ages combined
See related publication: https://doi.org/10.1016/S0140-6736(20)30925-9

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Democratic Republic of the Congo

What risk factors drive the most death and disability combined?

- Metabolic risks
- Environmental/occupational risks
- Behavioral risks

2009		2019		% change, 2009-2019
Malnutrition	1	1	Malnutrition	−44.0%
WaSH	2	2	Air pollution	−27.0%
Air pollution	3	3	WaSH	−53.0%
Unsafe sex	4	4	High blood pressure	20.9%
High blood pressure	5	5	High fasting plasma glucose	34.4%
Occupational risks	6	6	Occupational risks	1.1%
High fasting plasma glucose	7	7	Dietary risks	27.3%
Dietary risks	8	8	High body-mass index	83.3%
Tobacco	9	9	Alcohol use	67.8%
Alcohol use	10	10	Unsafe sex	−62.1%
High body-mass index	11	11	Tobacco	17.1%

Top 10 risks contributing to total number of DALYs in 2019 and percent change 2009–2019, all ages combined

See related publication: https://doi.org/10.1016/S0140-6736(20)30752-2

Highly prevalent in the artisanal mining sector

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Democratic Republic of the Congo

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Democratic Republic of the Congo

Air Pollution and Health Factsheet

Air pollution was **among the top 5 risk factors for death** in the DRC in 2019, accounting for nearly **12% of all deaths** (more than 70 thousand). Considered separately, ambient particulate matter ($PM_{2.5}$) ranked as the fifth leading risk factor for deaths, and household air pollution (HAP) ranked first. Ozone was not in the top 20 risk factors.

Key statistics at a glance for 2019

53% of the population of the DRC lives in areas where $PM_{2.5}$ levels are above the least stringent WHO guideline for healthy air (35 $\mu g/m^3$)

THE STATE OF AIR QUALITY AND HEALTH IMPACTS IN AFRICA

A REPORT FROM THE STATE OF GLOBAL AIR INITIATIVE

2022

The State of Global Air is a collaboration between the Health Effects Institute and the Institute for Health Metrics and Evaluation's Global Burden of Disease project.

HEI **IHME**

Citation: Health Effects Institute. 2022. The State of Air Quality and Health Impacts in Africa. A Report from the State of Global Air Initiative. Boston, MA:Health Effects Institute.
ISSN 2578-6881 © 2022 Health Effects Institute

Review article

Ambient air pollution and health in Sub-Saharan Africa: Current evidence, perspectives and a call to action.

Patrick D.M.C. Katoto[a,b,*], Liliane Byamungu[c], Amanda S. Brand[d], Jolynne Mokaya[d,e], Hans Strijdom[f], Nandu Goswami[g], Patrick De Boever[h,i], Tim S. Nawrot[a,i], Benoit Nemery[a,**]

Check for updates

Percentage of Deaths (by Cause) Due to Air Pollution in the DRC in 2019

38%	26%	35%	64%	35%	50%	20%
of stroke deaths	of diabetes deaths	of ischemic heart disease deaths	of COPD deaths	of lung cancer deaths	of lower-respiratory infection deaths	of neonatal deaths
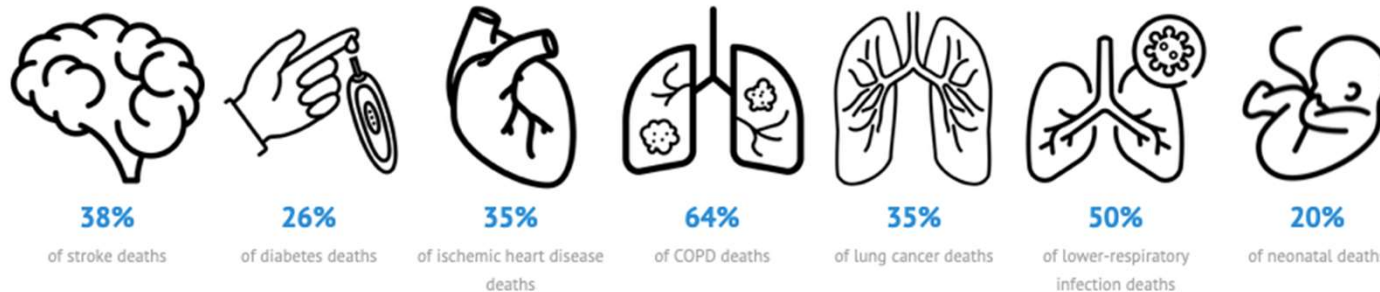
DRC: >95% of households rely on biomass for domestic energy (cooking, ...)

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Mycobacterium tuberculosis:
causative agent of tuberculosis (TB), is the number 1 infectious killer worldwide after COVID-19 infection.
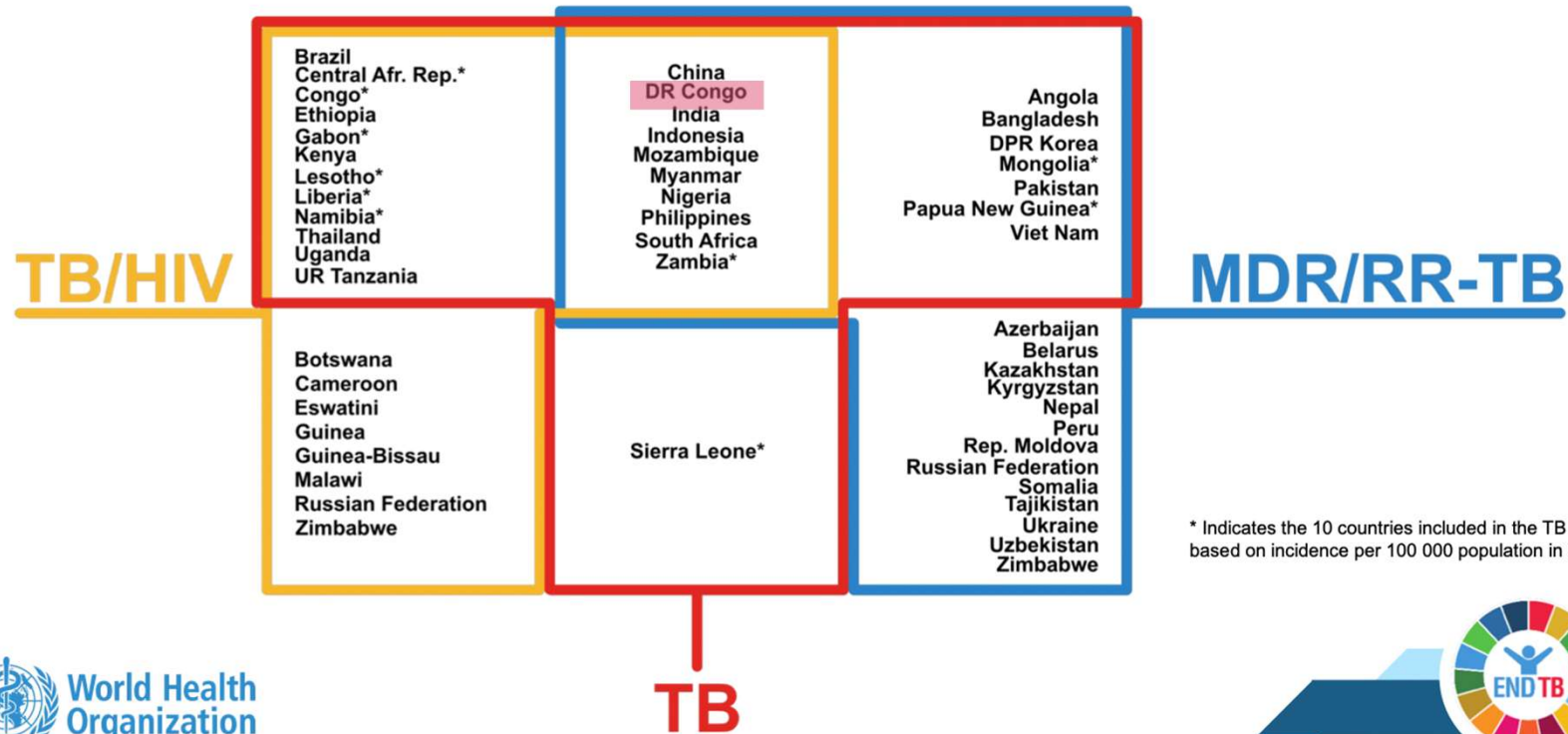
In 2022:
- **10 million** new cases
- **1.6 million** people killed

GLOBAL TUBERCULOSIS REPORT 2022 — World Health Organization
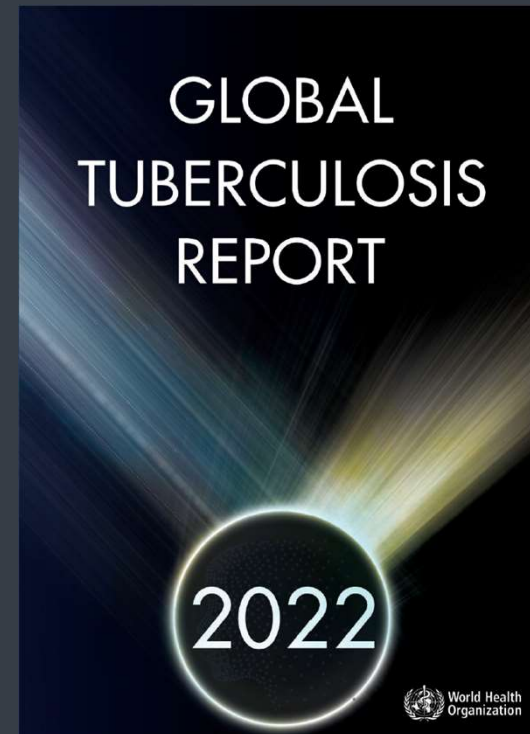
The 3 HBC lists to be used by WHO, 2021-2025

- 30 countries in each list; 49 countries in at least 1 list; 10 countries in all 3 lists

TB/HIV

MDR/RR-TB

TB

Brazil
Central Afr. Rep.*
Congo*
Ethiopia
Gabon*
Kenya
Lesotho*
Liberia*
Namibia*
Thailand
Uganda
UR Tanzania

China
DR Congo
India
Indonesia
Mozambique
Myanmar
Nigeria
Philippines
South Africa
Zambia*

Angola
Bangladesh
DPR Korea
Mongolia*
Pakistan
Papua New Guinea*
Viet Nam

Botswana
Cameroon
Eswatini
Guinea
Guinea-Bissau
Malawi
Russian Federation
Zimbabwe

Sierra Leone*

Azerbaijan
Belarus
Kazakhstan
Kyrgyzstan
Nepal
Peru
Rep. Moldova
Russian Federation
Somalia
Tajikistan
Ukraine
Uzbekistan
Zimbabwe

* Indicates the 10 countries included in the TB list based on incidence per 100 000 population in 2019

World Health Organization

END TB

WHO THREE I's MEETING

Intensified Case Finding (ICF), Isoniazid Preventive Therapy (IPT) and TB Infection Control (IC) for people living with HIV

REPORT OF A JOINT WORLD HEALTH ORGANIZATION
HIV/AIDS AND TB DEPARTMENT MEETING

2-4 APRIL, 2008, GENEVA, SWITZERLAND

RISK FACTORS

1. HIV: 13% of all TB cases are also HIV+

2. Chronic Lung Disease

3. Silicosis: 30 fold increase in risk

4. Smoking: twice the risk versus non-smokers

5. Others

Mining Air Pollution

Household Air Pollution

Biomass fuel smoke?

Project

EERRIK

Systematic Review:
AAP in SSA

GECAMINE Study (Coltan)

COST Study (HIV, TB, HAP)

TUMIKA Study (Gold Mining, TB)

BATUPE Study (Post-TB life, HAP)

Experimental

Coltan
(Nb+Ta)
- PO exposure
- IT exposure
- Wild rodents

Epidemiologic

- Questionnaire
- Biomonitoring :Urine-Blood, Nails-Sputum Food, dust, water

Case-control

- Clinical data
- Pollutants: CO, VOCs, 1-HP

Cohort

- Questionnaire
- Telomere Length
- mtDNA

- Clinical outcomes
- Metals+ 8OHdG

Cross-sectional

- IMPALA Questionnaire
- Respiratory symptoms
- Dyspnea
- Spirometry

13

A 44-y old mineworker « without left lung »

Multidrug Resistant Tuberculosis (MDR-TB)
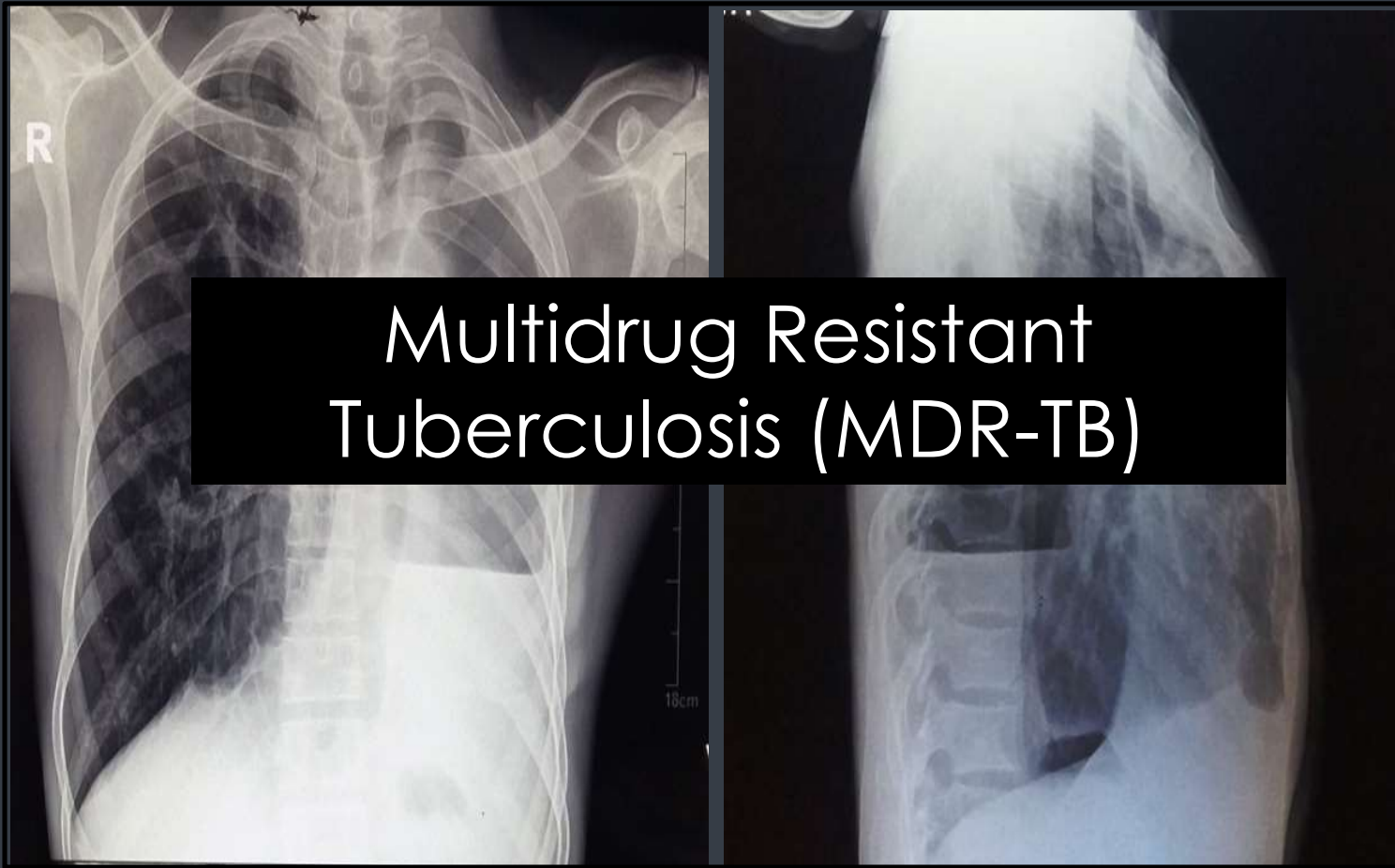
Incidence of Tuberculosis in 13 Health Zones in South Kivu, DR Congo (2016)
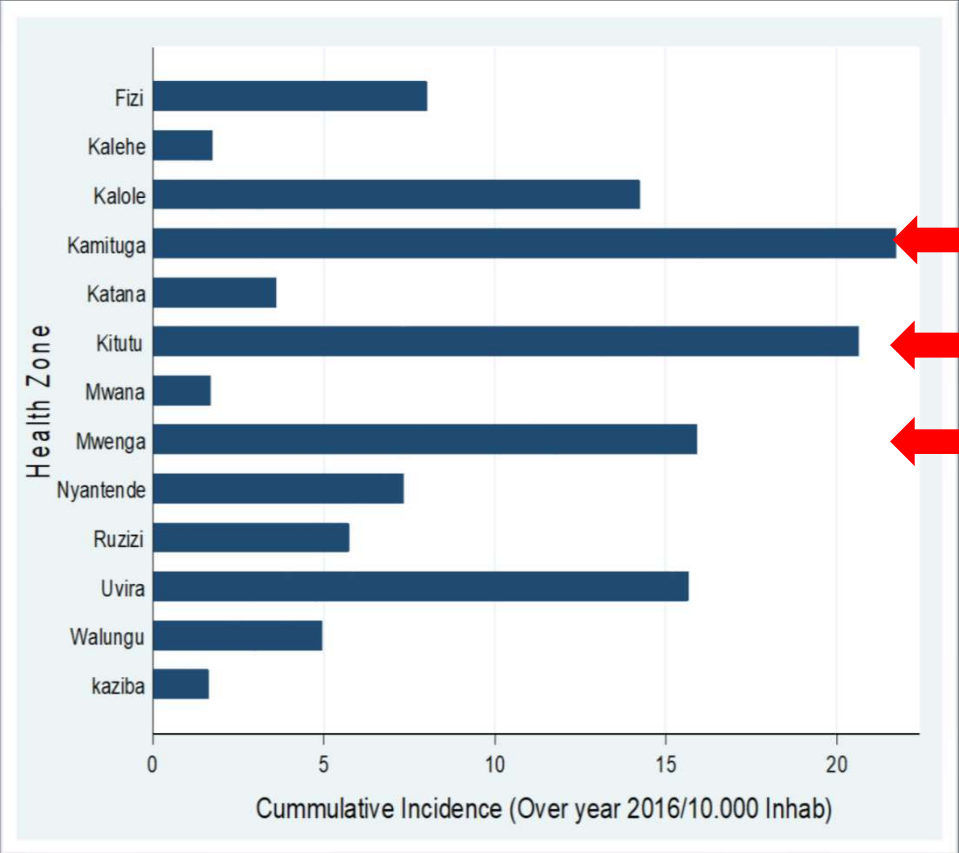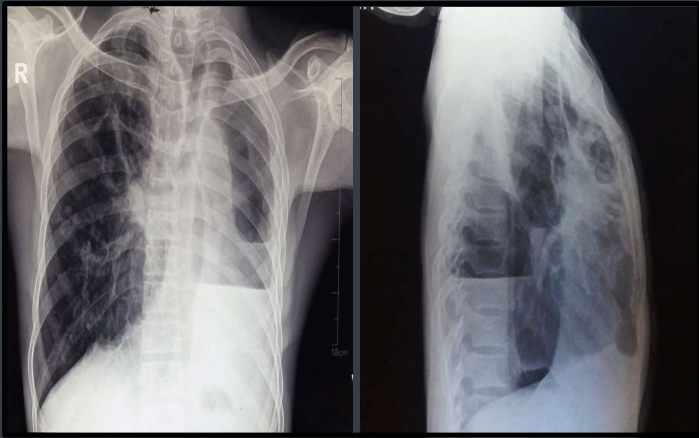
artisanal gold mining communities

Data are calculated from the South Kivu National Tuberculosis Program Database.

« bacimba »
« creuseurs »
(= diggers)

« twangueurs »
(= crushers)

TB CLINIC

TB clinic

HYPOTHESES

H1: PTB patients with a history of mining are more likely to fail their TB treatment

H2: Mining is associated with earlier cellular senescence, which might also independently predict TB treatment outcome.

TELOMERE LENGTH (TL)?
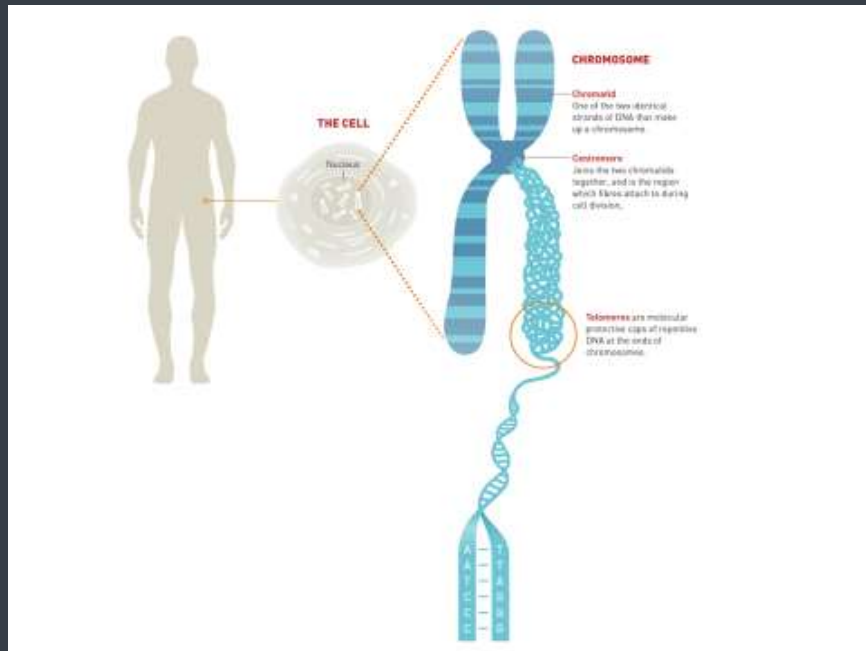
In somatic cells, successive divisions lead to shortening of telomeres (i.e. short telomeres reflect ageing)

TL in blood leukocytes is representative of ageing/senescence

Slide: courtesy of Prof. Tim Nawrot

METHODS: COHORT STUDY

- Cohort of 129 newly diagnosed PTB patients recruited from 3 health centres in a rural area with artisanal gold mines

  - 85 miners

  - 44 non-miners

- Clinical data (register + questionnaire)

- Blood (+urine)

  - Relative TL and mtDNA in peripheral blood leukocytes via qPCR (Hasselt)

- Endpoint: treatment success/failure at the completion of TB treatment (6 or 9 months later)

- Multivariable linear and Cox regressions

Results

$R^2=0.21$

non-miners
miners

Telomere Length

Age (years)
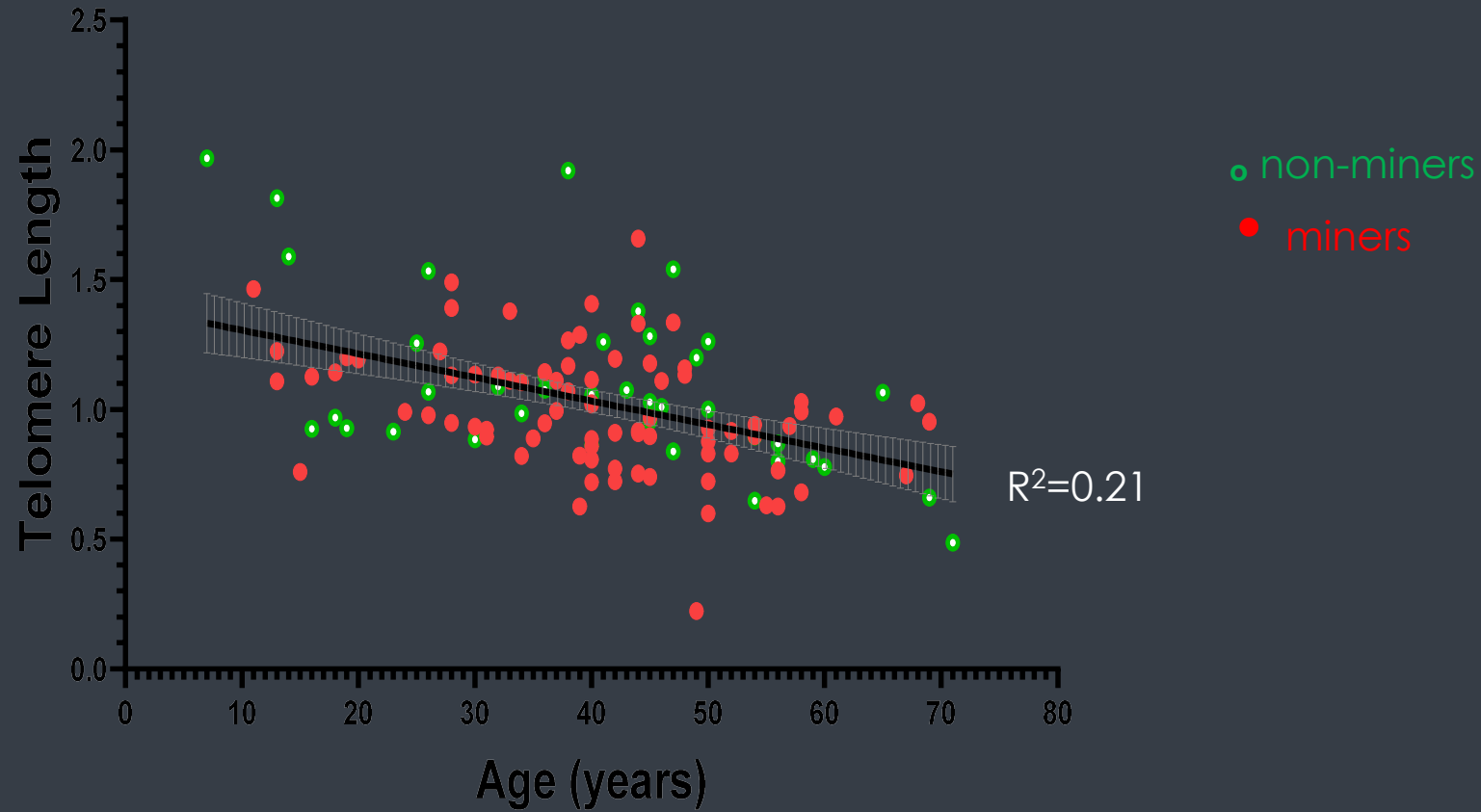
Results
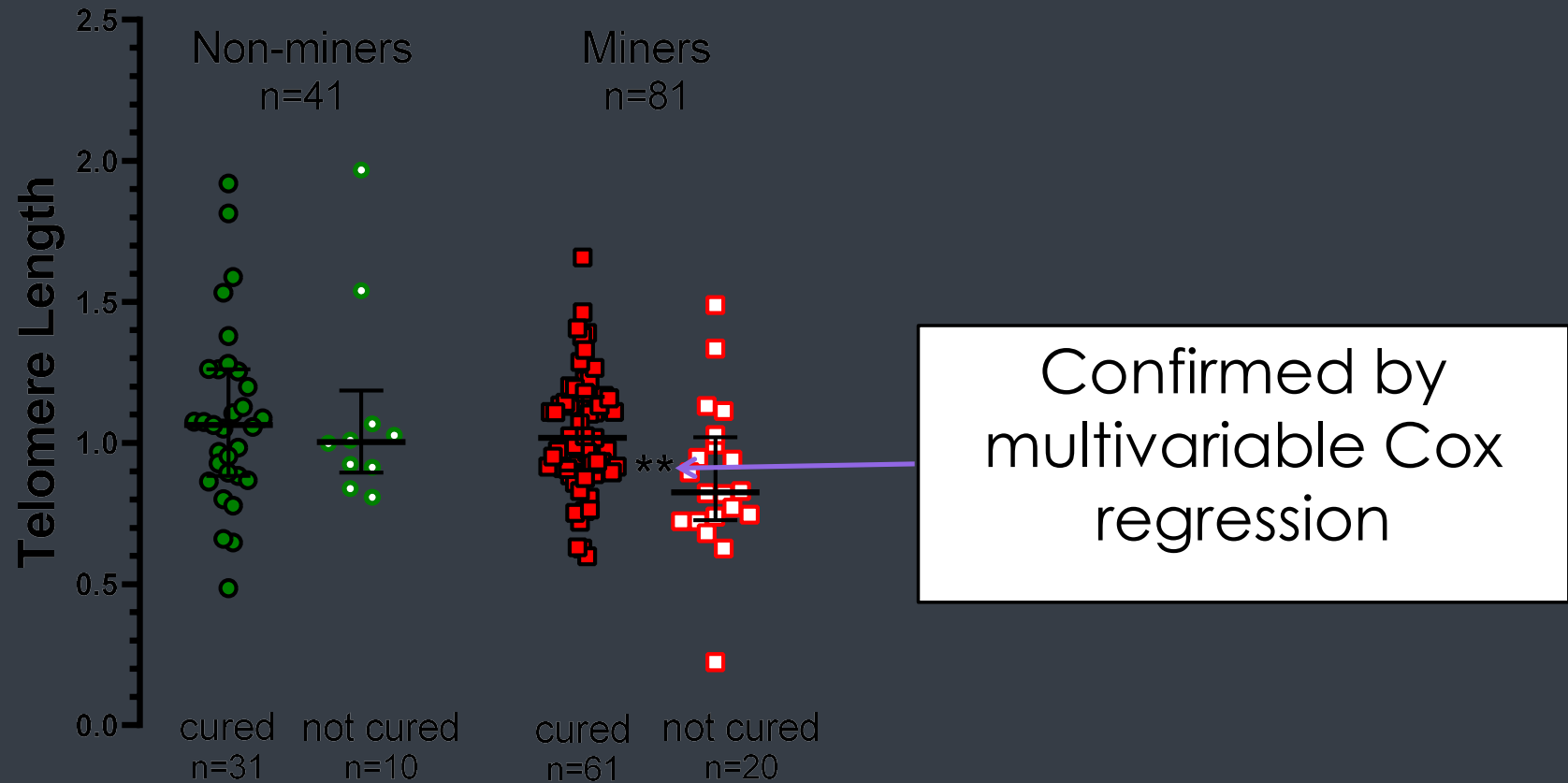
SUMMARY

TELOMERE LENGTH, A BIOMARKER OF AGEING, WAS ASSOCIATED WITH THE OUTCOME OF TREATMENT, ESPECIALLY AMONG MINERS.

INTERPRETATION? FOR A GIVEN **CHRONOLOGICAL AGE**, PERSONS THAT ARE **BIOLOGICAL OLDER** HAVE A **HIGHER RISK** FOR **TREATMENT FAILURE**.

TO BE CONFIRMED BY OTHER STUDIES

The association between silica exposure, silicosis and tuberculosis: a systematic review and meta-analysis

Rodney Ehrlich[1*] iD, Paula Akugizibwe[1], Nandi Siegfried[2,3] and David Rees[4,5]
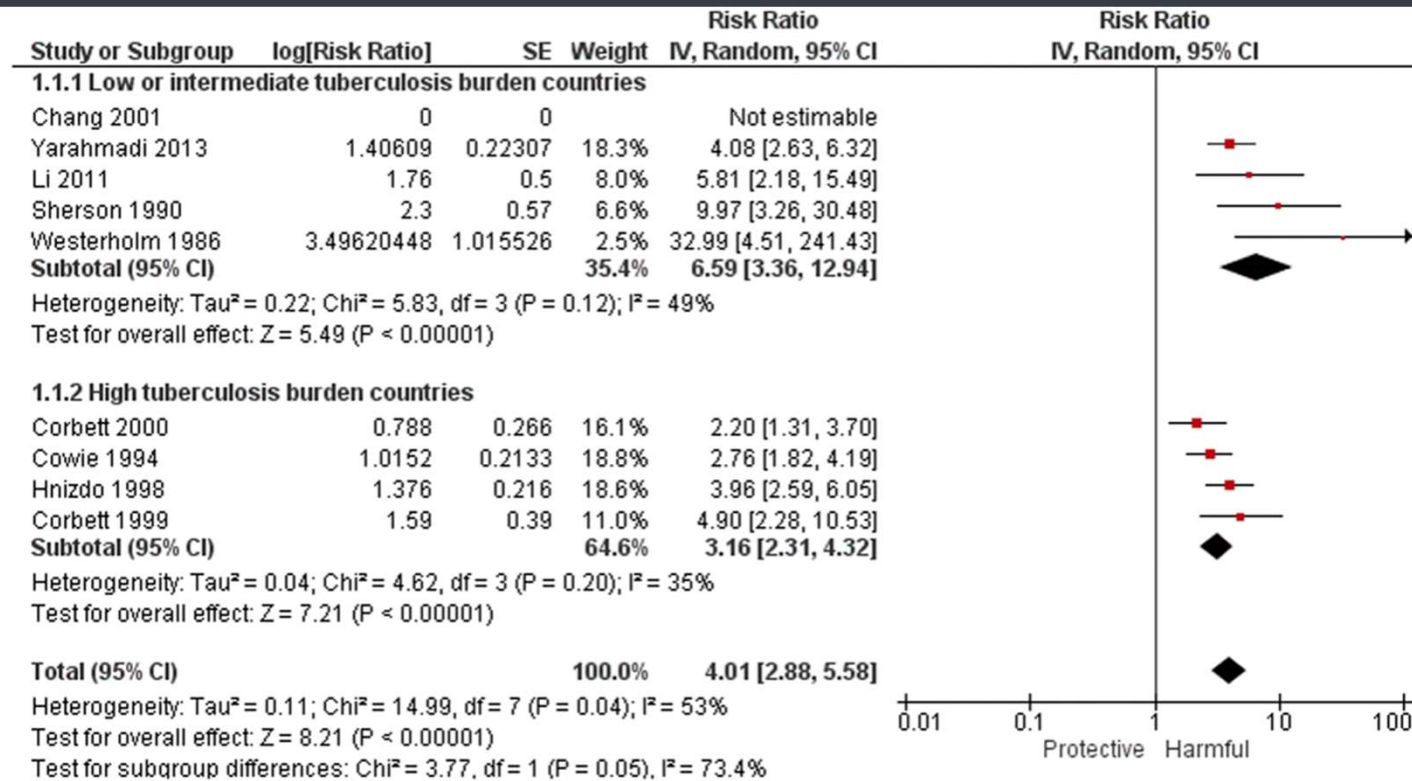
Forest plot: Studies of the association between silicosis and tuberculosis

POST-TB SEQUELAE

- 54 million survived TB between 2000 and 2017

- PIAT (Pulmonary impairment after TB): airflow obstruction, restrictive and fibrotic defects, bronchiectasis, aspergilloma, cancer …

- No normal life after a long treatment

- Not addressed in National TB Guidelines

- Effect of chronic exposure to HAP unknown

HYPOTHESIS

ARE RESPIRATORY SYMPTOMS AMONG PTB SURVIVORS IN RURAL SOUTH KIVU ASSOCIATED WITH EXPOSURE TO HAP ?

Setting and Design
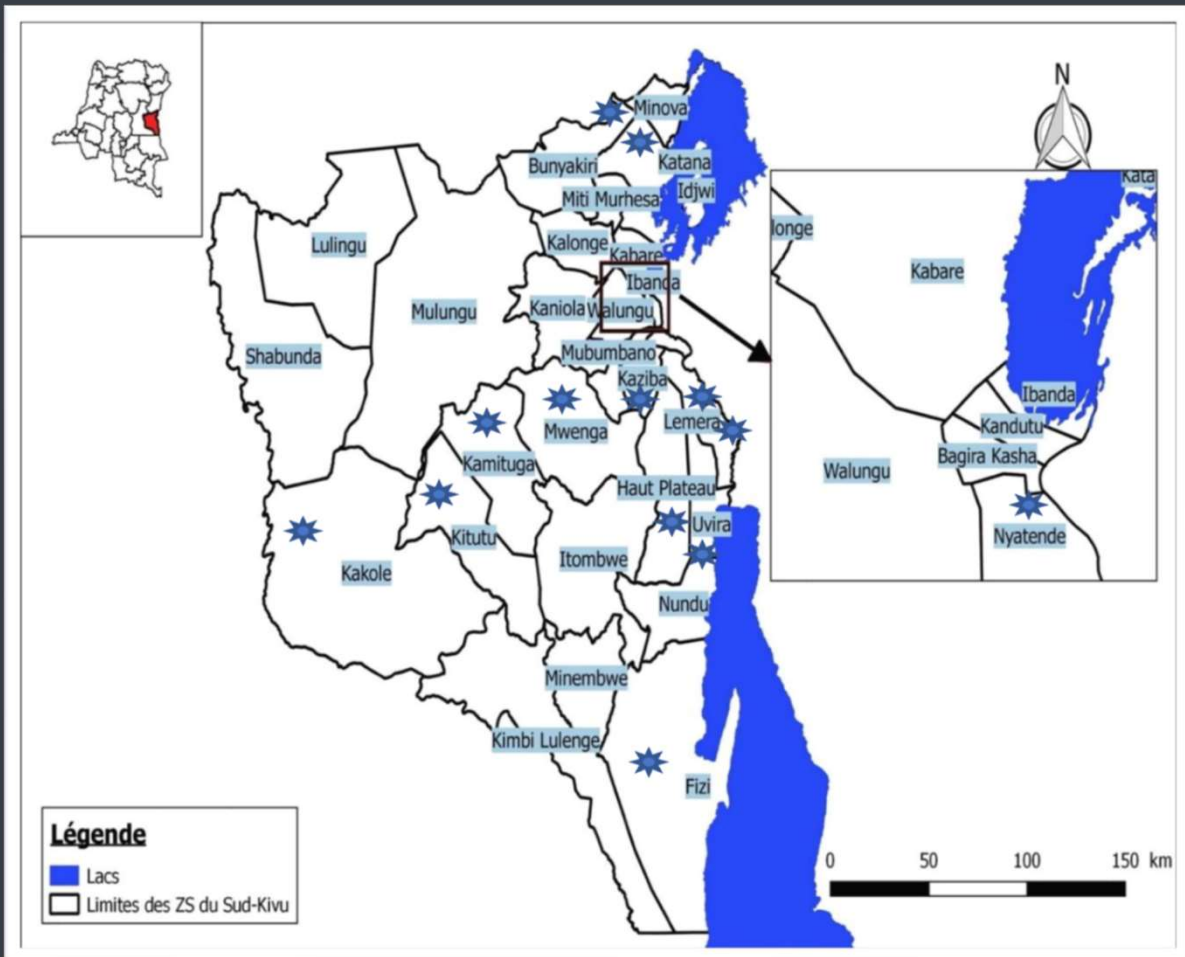
Cross-sectional study,

441 randomly selected PTB survivors living in 13 rural Health Zones with high TB burden in South Kivu

Trained community and health-care workers administered questionnaire.

Prevalence and predictors of **chronic cough** and **hemoptysis**

RESULTS

1) **Chronic Cough: aOR [95% CI]**

- HAP : 2.10 [1.10-4.00] vs no HAP
- daily time spent in the kitchen ⩾3hr: 2.74 [1.25-6.07] in women
- TB regimen > 6 months: 3.80 [1.62-8.96]

2) Hemoptysis:
- TB re-treatment: 3.04 [1.04-5.09]

SUMMARY

- Exposure to HAP proved a risk factor for chronic cough in PTB survivors, especially in women.

- This factor is amenable to intervention.

- Dyspnea and spirometry: to strengthen our findings

The relationship between GDP per capita and the prevalence of undernourishment, and TB incidence per 100 000 population, 2021[a]
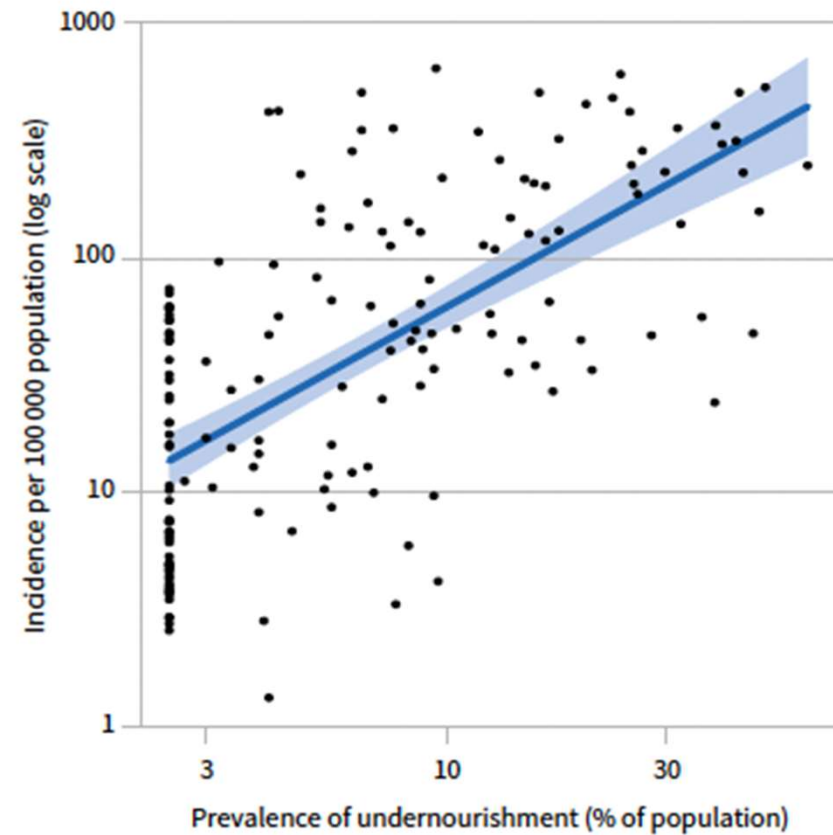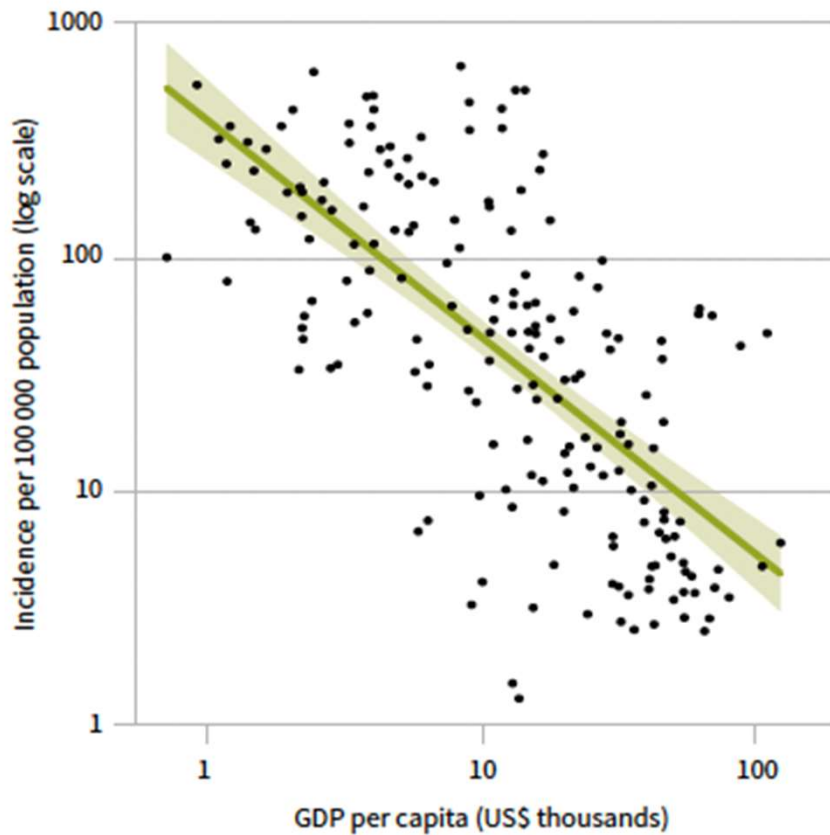
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IDSA Infectious Diseases Society of America | hivma hiv medicine association | OXFORD

Xpert *Mycobacterium tuberculosis*/Rifampicin–Detected Rifampicin Resistance is a Suboptimal Surrogate for Multidrug-resistant Tuberculosis in Eastern Democratic Republic of the Congo: Diagnostic and Clinical Implications

Bertin C. Bisimwa,[1,2] Jean B. Nachega,[3,4,5] Robin M. Warren,[6] Grant Theron,[6] John Z. Metcalfe,[7] Maunank Shah,[8] Andreas H. Diacon,[9] Nadia A. Sam-Agudu,[10,11] Marcel Yotebieng,[12] André N. H. Bulabula,[13,14] Patrick D. M. C. Katoto,[15,16] Jean-Paul Chirambiza,[17] Rosette Nyota,[17] Freddy M. Birembano,[17] Eric M. Musafiri,[17] Sifa Byadunia,[2] Esto Bahizire,[18,19,20] Michel K. Kaswa,[21] Steven Callens,[22] and Zacharie M. Kashongwe[1,2,23]

IDSA Infectious Diseases Society of America | hivma hiv medicine association | OXFORD

Prevalence, Predictors, and Successful Treatment Outcomes of Xpert MTB/RIF–identified Rifampicin-resistant Tuberculosis in Post-conflict Eastern Democratic Republic of the Congo, 2012–2017: A Retrospective Province-Wide Cohort Study

André N. H. Bulabula,[1,2] Jenna A. Nelson,[3] Eric M. Musafiri,[4] Rhoderick Machekano,[5] Nadia A. Sam-Agudu,[6,7] Andreas H. Diacon,[8] Maunank Shah,[9] Jacob Creswell,[10] Grant Theron,[11] Robin M. Warren,[11] Karen R. Jacobson,[12] Jean-Paul Chirambiza,[4] Dieudonné Kalumuna,[4] Bertin C. Bisimwa,[13] Patrick D. M. C. Katoto,[14,15] Michel K. Kaswa,[4] Freddy M. Birembano,[4] Liliane Kitete,[16] Martin P. Grobusch,[17] Zacharie M. Kashongwe,[18] and Jean B. Nachega[3,19,20,21]

Global Tuberculosis Report 2020 – Reflections on the Global TB burden, treatment and prevention efforts

Jeremiah Chakaya[a,b,*], Mishal Khan[c], Francine Ntoumi[e,f], Eleni Aklillu[g], Razia Fatima[d], Peter Mwaba[h], Nathan Kapata[i], Sayoki Mfinanga[j,k,l], Seyed Ehtesham Hasnain[m], Patrick D.M.C. Katoto[n], André N.H. Bulabula[o], Nadia A. Sam-Agudu[p,q,r], Jean B. Nachega[s,t,u], Simon Tiberi[v,w], Timothy D. McHugh[x], Ibrahim Abubakar[y], Alimuddin Zumla[z]
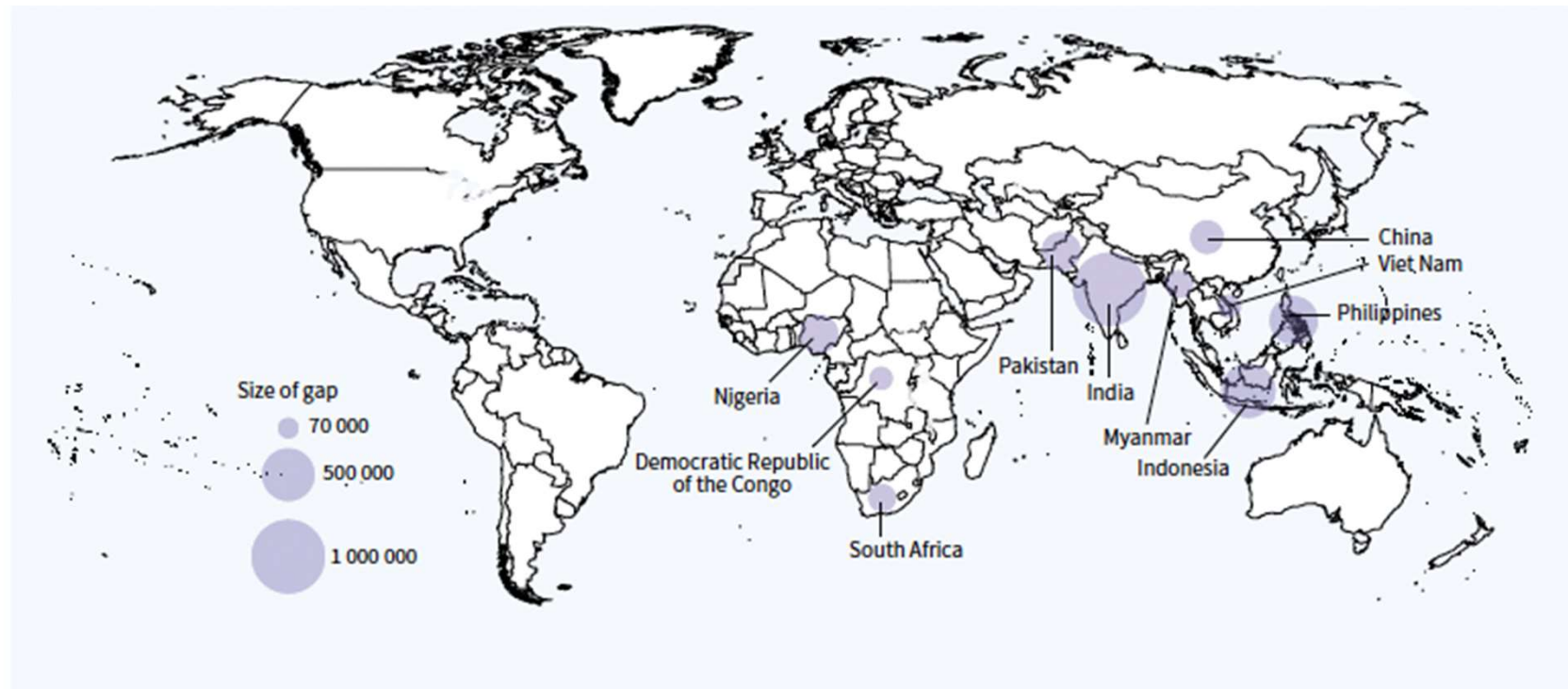
Africa's Miners Face New TB Threat as COVID-19 Pandemic Disrupts Treatment
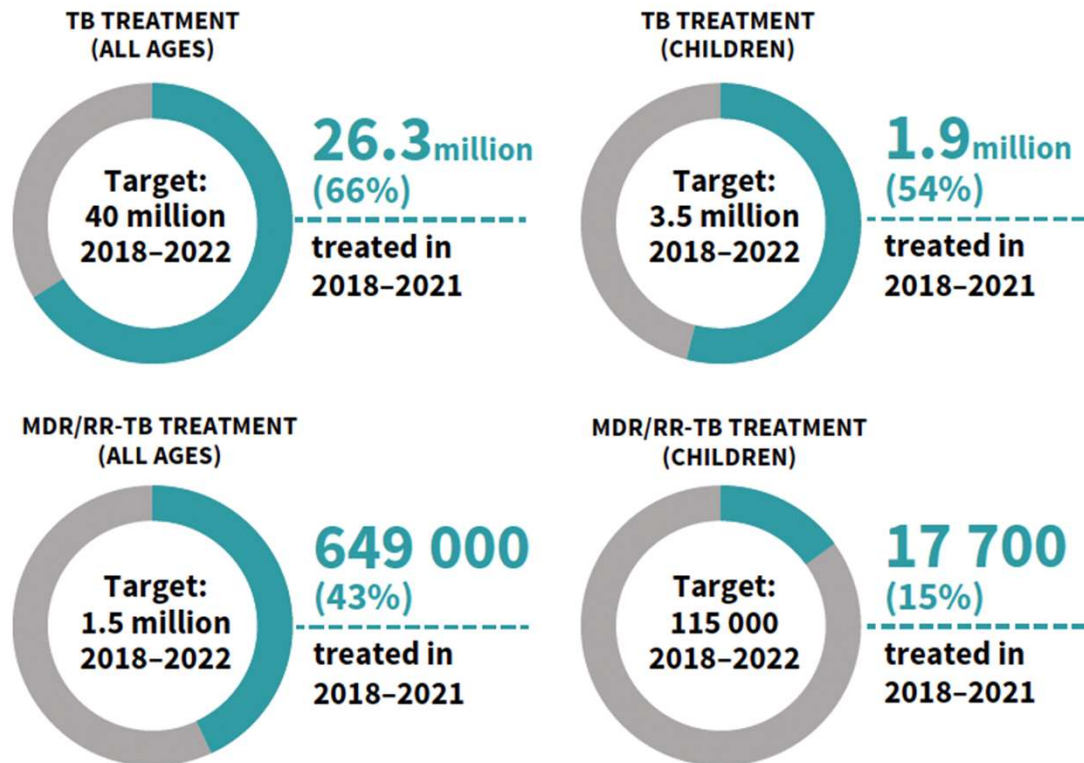

By Kim Harrisberg

FIRST PROBLEM

The ten countries with the largest gaps between notifications of new and relapse (incident) TB cases and the best estimates of TB incidence,[a,b] 2021

SECOND PROBLEM

Global progress in the number of people treated for TB between 2018 and 2021, compared with cumulative targets set for 2018–2022 at the UN high-level meeting on TB

TB TREATMENT (ALL AGES)

Target: 40 million 2018–2022

26.3 million (66%) treated in 2018–2021

TB TREATMENT (CHILDREN)

Target: 3.5 million 2018–2022

1.9 million (54%) treated in 2018–2021

MDR/RR-TB TREATMENT (ALL AGES)

Target: 1.5 million 2018–2022

649 000 (43%) treated in 2018–2021

MDR/RR-TB TREATMENT (CHILDREN)

Target: 115 000 2018–2022

17 700 (15%) treated in 2018–2021

THIRD PROBLEM

Estimates of the percentage of TB patients and their households facing catastrophic costs,[a] national surveys completed 2016–2022
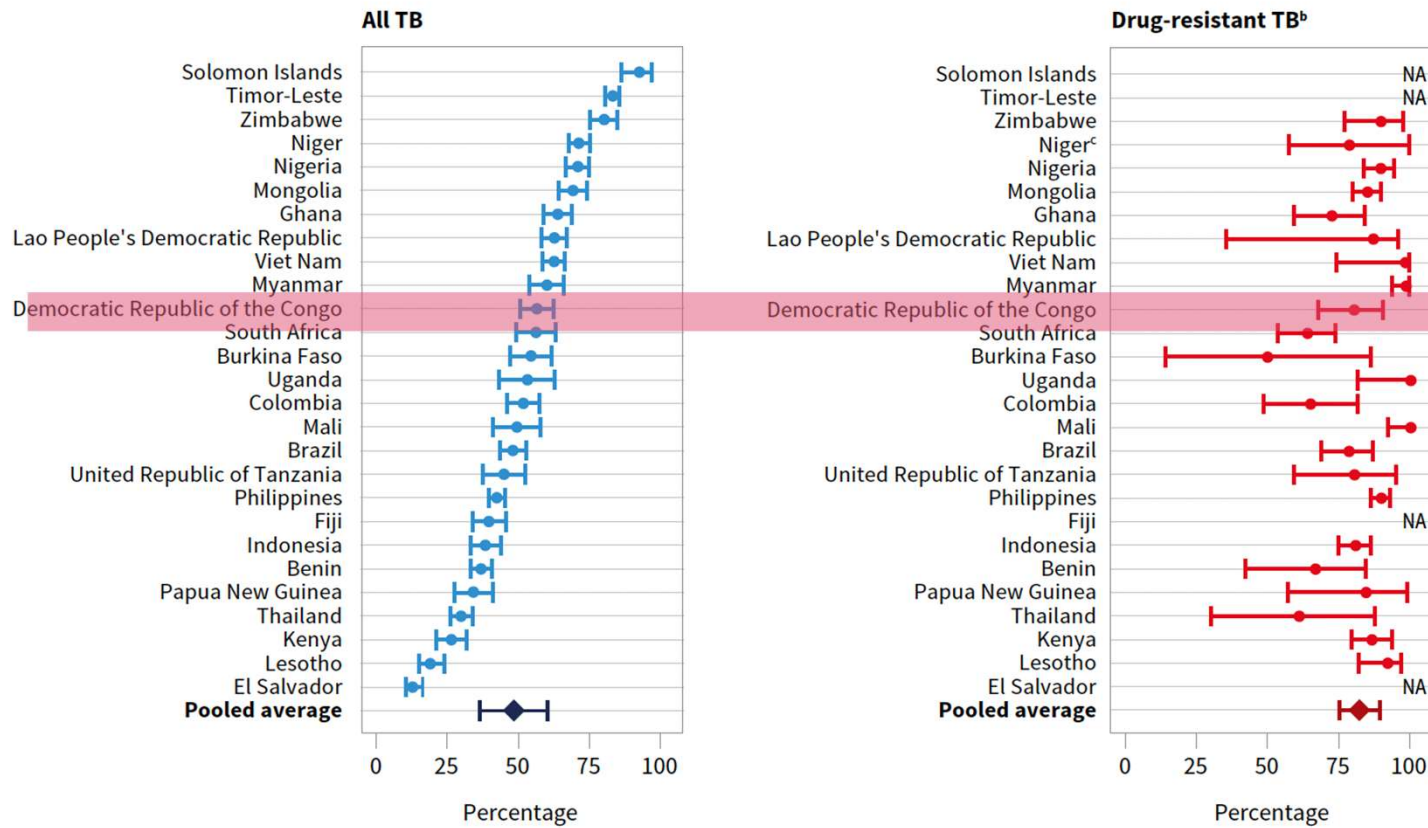
Pandemics are in the air?

Addressing the Colliding Epidemic of TB-(HIV)-(H-O-M)AP-COVID-19: a Model Towards Global Health Respiratory in Sub-Saharan Africa?
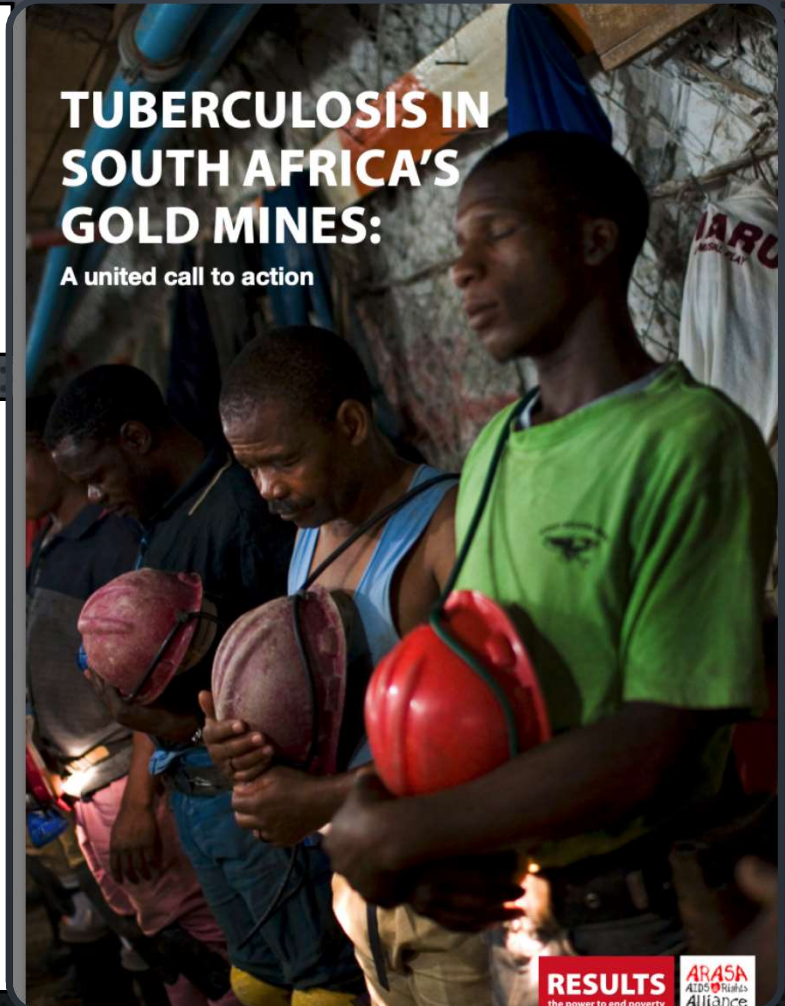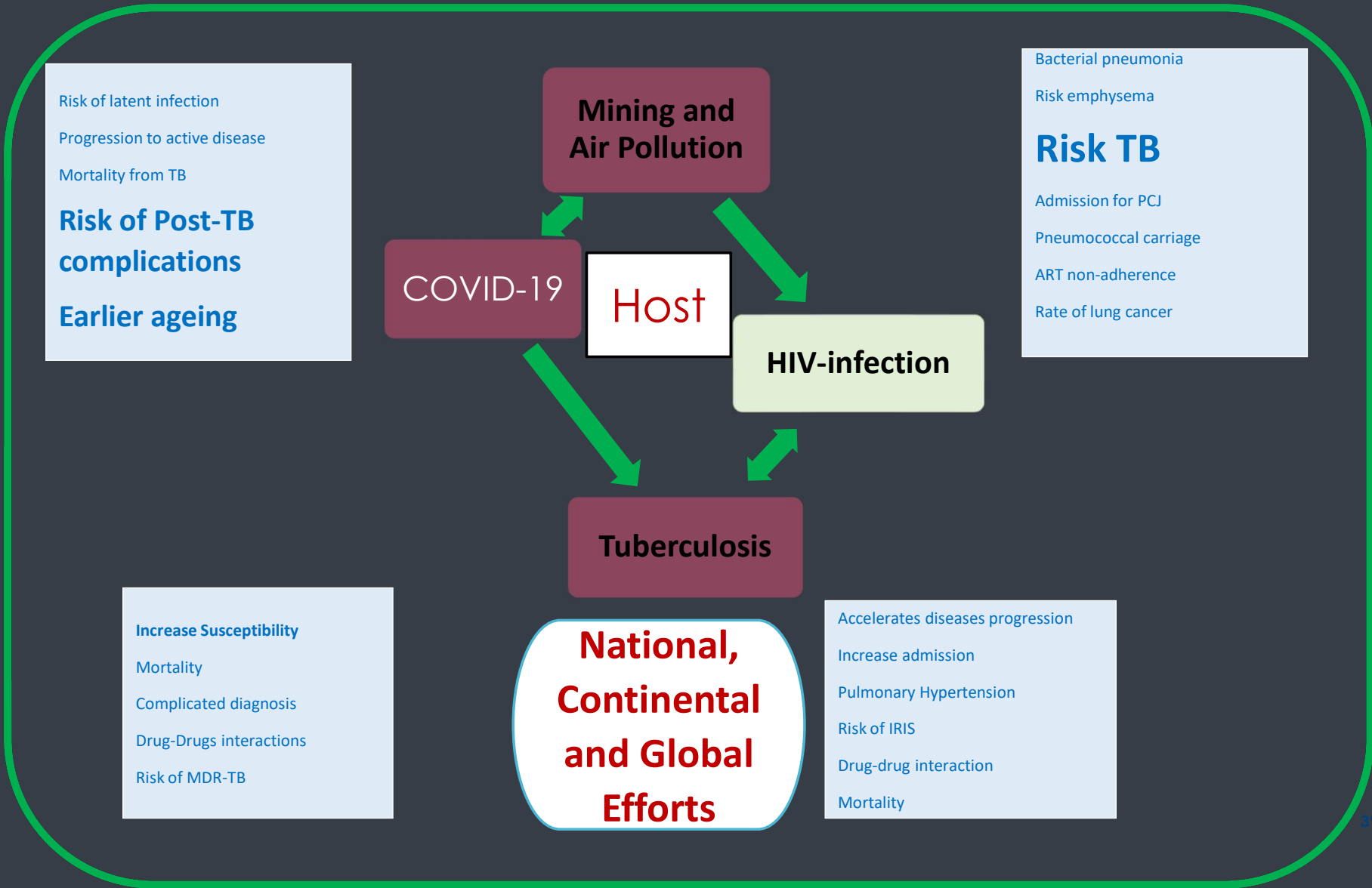
Sustainability of TB Service During COVID-19 Pandemic

Optimising TB Prevention

Tackling Determinants
- Poverty
- Undernutrition
- Alcohol-Tobacco
- Household air pollution
- Etc.

Reaching Specific Population
- HIV(+) and Diabetes (+)
- Prisoners
- Miners
- Aged below 15 years
- Etc.

Prioritising Active Case Finding
- Community leaders
- Community organisation
- Former TB patients
- Mobile clinics
- Etc

Re-thinking DOT
- Empowering patient and family
- Telemedicine/mHealth
- Community
- Mobile clinics
- Etc

Optimising TB Diagnosis and Treatment

Latent TB and Chemoprophylaxis
- Diagnose and treat in at high risk
- Short-term IPT in children and HIV in contact with TB patients
- Enhance research for latent TB

Active TB
- Increase testing for RR/MDR-TB
- Prefer short/ oral regimen
- Control for adverse drugs reaction
- Avoid unnecessary visit

Post-TB
- Assess quality of life
- Alert for TB relapse
- Screen NCDs such as COPD
- Etc

Improving Health System for TB

- Ensure continuity of care
- Double Xpert testing capacity
- Implement twin testing: TB-COVID-19
- Rolling in rapid testing for COVID-19 when available
- Address stigma, discrimination and other mental health's issues related to communicable diseases: TB-COVID-19
- Improving health system surveillance, data sharing and elaborate consistent national policy
- Pro-active planning, procurement, chain supply, risk management to overcome logistic issues
- Capacity building and rigorous infection, prevention and control for both TB-COVID-19 to protect health workers

DRC, VERY BEHIND IN ADDRESSING TB IN THE MINING?

Is a DRC TB IN MINING KNOWLEDGE Receipt required?

- BUILDING HEALTH LITTERACY
- RESILIENT HEALTH SYSTEM
- EXPENDING UHC
- OTHER NON-PHARMACEUTICAL INTERVENTIONS
- PHARMACEUTICAL INTERVENTION

IT IS POSSIBLE TO END TB

Cumulative number of deaths averted by TB and TB/HIV interventions 2000–2021 (in millions), globally and by WHO region[a]

WHO REGION	HIV-NEGATIVE PEOPLE		HIV-POSITIVE PEOPLE		TOTAL	
	BEST ESTIMATE	UNCERTAINTY INTERVAL	BEST ESTIMATE	UNCERTAINTY INTERVAL	BEST ESTIMATE	UNCERTAINTY INTERVAL
African Region	7.1	6.0–8.3	8.5	7.2–9.8	16	14–17
Region of the Americas	1.9	1.8–2.1	0.36	0.33–0.39	2.3	2.1–2.4
South-East Asia Region	30	25–34	2.9	2.0–3.8	32	28–37
European Region	2.1	1.9–2.4	0.32	0.28–0.35	2.4	2.2–2.7
Eastern Mediterranean Region	5.2	4.6–5.8	0.10	0.08–0.12	5.3	4.7–5.9
Western Pacific Region	16	14–17	0.50	0.42–0.59	16	15–18
Global	62	55–69	13	11–14	74	67–81

[a] Numbers shown to two significant figures.

FOR THEIR FUTURE…

ASANTI SANA

ACKNOWLEDGEMENT

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ROTARY CLUB BRUGGE

LTU-KUL

ALFAGEN
VLIR-UOS

Centre for Evidence base, Stellenbosch University and Africa, Cocchranne collaboration

ATS MECOR

PATS MECOR

Université Catholique de Bukavu,

HPGRB, HGR PANZI, PNLT-SUD-KIVU, PHARMAKINA, BDOM, CEGEMI/USOS, WATER AND SOIL AND GEOLOGY DIVISION, KUL

BUKAVU INFECTION DISEASES GROUP (BIG)

Grand Seminaire Murhesa PIE X