

TB Modelling and Analysis Consortium (TB MAC)

**Modelling socio-economic determinants and interventions for TB -
what do we know, where do we go?**

New York City, United States of America

13-14 October 2015

Meeting Report

www.tb-mac.org

TABLE OF CONTENTS

Executive summary		3
1.1	TB Modelling and Analysis Consortium (TB MAC): Background, Aim, Objectives	4
1.2	TB MAC Meeting 7: Modelling socio-economic determinants and interventions for TB – what do we know, where do we go? Objectives; Background; Preparation; Structure	5
1.3	Summary of plenary presentations (Day 1)	6
1.4	Group discussions and priority research questions (Day 2)	7
1.5	Request for Applications	8
	<u>Question Area 1: Assessing the impact of reaching Sustainable Development Goals (SDGs) on TB epidemiology</u>	8
	<u>Question Area 2: Using natural experiments to identify mechanisms by which Socio-economic and structural factors influence TB</u>	8
1.6	Outcomes and next steps	9
Appendices		
2.1	Summary of selected papers for area discussions	10
2.2	Agenda and Participant List	25
2.3	Potential ideas for TB MAC RfA call – full list	29

Executive summary

The TB Modelling and Analysis Consortium (TB MAC) is an initiative to improve global tuberculosis (TB) control by coordinating and promoting mathematical modelling and other quantitative research activities.

At our seventh meeting, held in October 2015 in New York, our aims were to set out a path towards including socio-economic trends and interventions into mathematical models of TB. We brought together experts from different fields, including social epidemiologists and epidemiological modellers, health economists, and representatives from policy bodies, including the UNDP, World Bank and WHO to share ongoing analyses and shape the direction of future modelling research in this area. Specific focus was given to develop concrete work outlines that would incorporate distal and proximal socio-economic indicators in epidemiological models of TB. In addition, a broad overview was provided on the landscape of including socio-economic interventions into multi-intervention evaluations, specifically focussing on social transfer programmes and co-financing of interventions.

After series of presentations, the participants separated into working groups to formulate a set of project outlines which would advance the field of modelling socio-economic determinants, and could be completed by end of 2016. TB MAC has released a Request for Applications covering these eight areas, with 200,000 USD of funding to be awarded by end of 2015.

1.1 TB Modelling and Analysis Consortium (TB MAC)

Background

The complex natural history of TB, range of possible interventions and great variation in epidemiological settings, mean that TB policy makers and donors face great uncertainty when prioritising TB control activities.

This uncertainty can be reduced and quantified, and the cost-effectiveness of different strategies compared, using mathematical modelling and other quantitative research activities. Several groups of modellers worked separately on issues such as the impact of new diagnostics, drugs and vaccines, but although this work has contributed greatly to understanding the transmission and control of TB, the influence of the work was weakened by a lack of co-ordination, information-sharing, consensus building and prioritisation.

This led to critical research gaps and conflicting policy recommendations which served TB control poorly. Policy making and resource allocation must be based on scientific consensus derived from best analytic inputs, which draw on data and models in epidemiology, economics, demography and related disciplines. The TB Modelling and Analysis Consortium (TB MAC, www.tb-mac.org) aims to improve the interaction between quantitative researchers, policy makers, TB programmes and donors to improve global control. A first meeting (September 2013, Johannesburg) focussed on TB control in high HIV settings. TB MAC's focus then shifted to diagnostics and drugs, followed by a multi-model comparison exercise to evaluate the feasibility of the End TB Strategy targets in China, India and South Africa.

TB MAC Aim

To improve global TB control by coordinating and promoting mathematical modelling and other quantitative research activities to provide scientific support for policy decisions and implementation.

TB MAC Objectives

- 1) **Identify research questions** concerning TB control that require input from mathematical modelling or other quantitative research
- 2) Facilitate **sharing of data, information and expertise** to achieve consensus on current knowledge and knowledge gaps, methodological standards and current best practice for TB control decision-making
- 3) **Fund** small analytical /modelling research projects
- 4) **Disseminate results and tools** to key stakeholders including TB control programmes and donors

1.2 TB MAC meeting 7: Modelling socio-economic determinants and interventions for TB - what do we know, where do we go?

This report describes the third TB MAC meeting in New York City, United States of America which covered the research area of modelling socio-economic determinants and interventions for TB.

Meeting objectives

Aim: set out path towards including socio-economic trends and interventions into mathematical models of TB

Objective 1: Develop work outlines to incorporate in distal and proximal socio-economic indicators in epidemiological models of TB

Objective 2: Articulate landscape of including socio-economic interventions into multi-intervention evaluations through 2 main topics:

2.1: Social transfer programmes

2.2: Co-financing: Costing of TB specific versus general socio-economic interventions

Background to meeting

No disease in history has been so associated with poverty and its associated stigma as tuberculosis (TB). As we enter the era of Sustainable Development Goals, with its strong focus on extreme poverty reduction, and the post-2015 End TB Strategy, TB programme policies must act outside their silos to maximise the benefits of *cross-disease* activities that address socio-economic or structural determinants of TB. Mathematical Modelling is a powerful tool to inform policy discussions and demonstrate the potential value, for example, of nutrition programmes and Universal Health Coverage for TB. However, current mathematical models do not usually capture the well-established relationships between trends in socio-economic or structural determinants and TB burden, mainly driven by incomplete understanding of the exact mechanism by which distal (e.g. Gross Domestic Product) or even proximal (e.g. nutrition, crowding) determinants change the natural history of TB.

Given the changing policy and finance landscapes for health and development, modelling needs to rethink this status quo to remain relevant and provide systematic approaches to the shifting paradigms. In this seventh TB MAC meeting, we aimed to set out a path towards including socio-economic trends and interventions into mathematical models of TB. The meeting was followed up by a funding call for projects that would advance the field.

Meeting preparation

A review of existing work was done and distributed to participants before the meeting, to allow discussions to rapidly move beyond the status quo. Please see the review document in Appendix 2.1

Structure and process of meeting

The meeting was structured into one full day of presentations and discussion panels and a second day of small working group discussions and reporting, as can be seen in the meeting agenda (Appendix 2.2).

After a day of plenary presentations about the current challenges and policy landscape in TB, experiences from other fields (e.g. HIV) and experiences from individuals who have worked in the area, day 2 focussed on working groups generating ideas for specific work packages that would fit the funding call. Each group would discuss their respective ideas during breakout sessions, and feed back interim ideas to the plenary group for wider input. Taking these comments into account, the groups then prepared their final list of key questions, and a draft Request for Applications, which were presented during the final plenary meeting.

1.3 DAY 1: Where are we now?

1.3.1 Modelling socio-economic determinants and interventions for TB - what do we know, where do we go?

After introductory remarks by the chair of TB MAC (Richard White, LSHTM), Rein Houben (LSHTM) delivered an opening presentation outlining the clear need for models to develop in the area of socio-economic or structural determinants, but also the challenges faced. In particular, uncertainty of the exact mechanism through which distal or proximal determinants change the natural history as captured by TB dynamic transmission models. Which parameters are affected (progression, mixing, immunity, etc...), what is the dose-response relationship, and is that relationship the same for all parameters are just some of the questions faced by modellers. However, it was made clear that the modelling community needs to take up the challenge to remain useful for policy discussion.

1.3.2 Socio economic determinants and TB

Knut Lönnroth (WHO/GTB) presented the global policy landscape, and how both the SDGs and End TB strategy have socio-economic and structural determinants as key priorities. He also summarised definitions for core concepts such as social protection, Universal Health Coverage and catastrophic costs, and the challenges with measuring progress against these concepts. Through the interplay between TB and a wide range of poverty and development related determinants that are part of the 17 SDGs, it was made clear that TB has strong links throughout this agenda. This enforced the notion that TB research and policy needs to look outside its own silo for policy and co-funding opportunities. Finally, some of the existing modelling and data evidence was summarised, to highlight that there is a foundation of work and knowledge to build from.

1.3.3 The global landscape of social transfer programmes for health

Nicole Fraser-Hurt (World Bank) presented an excellent global overview of the social transfer portfolio, with on average 20 social transfer programmes active in a developing country, across disease and development areas, which form a critical part of the WB mission to ending extreme poverty by 2030. In addition, she outlined the spectrum of characteristics of social transfer programme, including whether they are sensitive or specific to a particular health condition, cash-based, conditionality, frequency and delivery mode, and the challenge of identifying the price point – what should the value of the transfer be to achieve the desired outcome? Finally she discussed the evidence to support social transfers, which is uneven but strong for livelihoods, education and health.

1.3.4 Principles of co-financing socio-economic interventions

Anna Vassall and Michelle Remme (LSHTM) presented on their work in HIV on a method to determine how different programmes could contribute to the cost of implementing socio-economic interventions. Such interventions are usually too costly for a single disease programme to fund, but also have benefits for other areas, such as education and economic production. Through a method of monetizing health and other benefits, and weighing the relative benefit and ability to pay for each programme, a division of total costs across programmes could be proposed. To enable this approach, studies should measure additional benefits (schooling, poverty, economic production etc...) of interventions, e.g. go beyond the standard TB outcomes. Without such information, the intervention studied is less likely to be implemented at country level, as the argument for the necessary co-funding cannot be made.

In addition, the presentation introduced the STRIVE consortium, which brought together a range of disciplines to tackle research questions around structural drivers of HIV.

1.3.5 Applications of co-financing in countries

Douglas Webb (UNDP) described the implementation of the co-financing approach as proposed by the previous presentation. During a workshop in April 2015, policy makers from different departments in the government of South Africa, Malawi, Tanzania and Ethiopia, countries discussed specific interventions, and how they might be co-financed. This is an ongoing process, with high engagement from the countries involved. The presentation also expanded on the point made by Knut Lönnroth regarding the opportunities within the SDGs for TB as a contributor or metric of a wide range of goals.

1.3.6 Discussion panel: Is TB different?

Three speakers (Delia Boccia – LSHTM, Jason Madan (Warwick University) and Philip Eckhoff (IDM)) presented their views on how TB was different, or not, from other disease areas when trying to incorporate socio-economic and structural determinants in modelling.

1.3.7 Lessons learned and challenges faced with modelling TB and socio-economic or structural determinants

Four short presentations by researchers who have published work in this area (Andrew Siroka – GTB, Aaron Reeves – Oxford, Jason Andrews (Stanford) and Olivia Oxlade (McGill)) shared their main findings (see also the systematic review in Appendix 2.1, but mainly the key lessons that they learned, and challenges faced in their work.

1.3.8 Discussion panel: Next steps for TB Epi Modelling and socio-economic determinants

This final discussion panel was meant to feed into discussions on day 2, and provide the perspective from two world leading TB modellers (Ted Cohen – Yale and David Dowdy – Johns Hopkins) as well as an NTP (Dr Hoa Nguyen – Viet Nam NTP) on what the next steps are. The discussion covered the recognition on the need for work in this area, but also the challenges from our gaps in understanding.

1.4 DAY 2: Where do we go?

For this day, participants were divided into 4 groups and tasked to each produce two research questions that would advance the field of modelling of socio-economic and structural determinants of TB, and could be completed by December 2016.

The resulting questions were shown in the table below, which has gone out as part of a Request for Applications, which can be viewed at <http://www.tb-mac.org/RFAs/RFA/9> . During the meeting, participants were asked to give their preference for the most urgent and useful question. The first two listed here stood out clearly : (for the full list of RfA questions considered, please see appendix 2.3 on page 29).

1.5 Outlines for areas of particular interest

Title	<i>Assessing the impact of reaching Sustainable Development Goals (SDGs) on TB epidemiology</i>
Research Gap to address	<p>There is general support for cross-sectoral planning with SDGs, but need for actual dialogue on the most promising entry points. Better data is needed on the incremental effects of structural interventions to address structural and socio-economic determinants of TB. Few mathematical models have included upstream structural and socio-economic determinants.</p> <p>Epidemiological data is available for assessing the association between risk of TB and, for example, poverty and undernutrition. Ecological (mainly cross-sectional and cross-country) analyses have been done on the association between TB rates and macroeconomic indicators, social protection spending and reduction in undernutrition prevalence. However, longitudinal analysis of the impact of change in these, or other socio-economic/structural parameters over time in a given country has not previously been done.</p> <p>Projects in this area should address the effects on TB epidemiology of activities targeting at least one (and preferably more than one) SDG.</p>
Title	<i>Using natural experiments to identify mechanisms by which Socio-economic and structural factors influence TB</i>
Research Gap to address	<p>There is evidence of association between structural and socio-economic determinants and drivers of TB transmission (e.g., time to diagnosis) and natural history (e.g., progression after infection). However, quantitative evidence of a mechanistic link is often lacking. Natural experiments that impact structural and socio-economic factors (e.g., UHC, tobacco, social policies, urbanization, war) are a potentially rich, but underused source of data to inform these links.</p> <p>A project in this area would mine data from natural experiments to quantify the links between changes in structural and socio-economic determinants and mechanisms that can be included in TB mathematical models. If possible within the time frame, modelling work that illustrates the impact of this change will be preferred. If modeling is not possible, please clarify how the analysis conducted will feed into future models.</p>

1.6 Outcomes and next steps

The meeting was successful in its aim and objectives. Another outcome is the potential for new collaborations across institutions and disciplines, which will hopefully be reflected in the applications for the RFA, and successful completion of these projects. Through this work we hope to rapidly expand the work that is urgently needed to keep TB modelling relevant in a rapidly changing global policy landscape.

APPENDICES

- 2.1 Summary of selected papers for area discussions
- 2.2 Meeting agenda + participant list
- 2.3 Potential ideas for the TB MAC RfA call – full list

Appendix 2.1 Summary of selected papers for area discussions

TB MAC 7: Modelling socio-economic determinants and interventions for TB control: What do we know, where do we go?

Summary of selected papers for meeting discussions

This document provides a short summary of key publications with high relevance to the discussions. We did not include systematic reviews or observational epidemiological studies looking at proximate determinants of TB.

All papers can be downloaded using the following link <https://goo.gl/uF9HjG>. If you have a Google account and are logged in, you can right click on the folder you wish to download and choose 'Download'. This will start the download of the zip-file.

1: Epidemiological impact of social determinants of TB: ecological analyses

Ref	Aim of the Study	Key social/structural determinants/socioeconomic indicators investigated	Setting	Conclusion(s)
(1) (Reeves, 2014)	To test whether alternative social protection programmes have affected TB case notifications, prevalence, mortality, case detection and treatment success rates in 21 European countries from 1995 to 2012	Social protection, GDP, Public health (measure of government investment in disease detection and prevention)	Europe	Each US\$100 increase in social protection spending was associated with a decrease in the number of TB case notifications, in TB incidence rates, in TB mortality rate. No relation between increased social spending and TB prevalence per increase of \$100 or smear-positive treatment success rates per increase of \$100, or case detection per increase of \$100. Old age pension expenditure seemed to have the strongest association with reductions in TB case notification rates for those aged 65 years or older

(2) (Reeves, 2015)	To test whether the economic recession and associated budgetary reductions in infectious disease control programmes affected TB control in the European Union	Government expenditure per capita on public health services. GDP and cumulative decline in GDP during the recession period as a measure of the severity of the recession	Europe	Across the European Union, reductions in spending on public health services appear to have reduced TB case detection. The recession (2008-2011) and consequent austerity policies will lead to increases in TB prevalence and TB-attributable mortality that are projected to persist for over a decade
(3) (Siroka, 2015)	To show the association between the levels of social protection and TB prevalence, incidence and mortality rates	Levels of social protection measured as the percentage of national GDP spent on social protection programmes (excluding health)	World	Association between social protection spending (as a % of GDP) and TB prevalence, incidence and mortality. Especially true in settings with low levels of social protection spending
(4) (Dye, 2009)	To determine whether differences in national trends in TB incidence are attributable to the variable success of control programmes or to biological, social and economic factors	Measures covering development, economy, population, behavioural and biological risk factors, health services (life expectancy from birth, under five mortality, measles vaccination coverage), TB control	World	Recent trends in TB incidence are more strongly associated with biological, social and economic determinants (human development index, child mortality, sanitation)
(5) (Janssens, 2008)	To explore and illustrate the relationship between TB incidence and GDP	GDP	World	Each doubling of GDP is associated with a 38.5% decrease in TB incidence
(6) (Suk, 2009)	To explore the correlation between communicable diseases and wealth distribution using TB as a case study	Gini coefficient; Eurostat's inequality of income distribution ratio (which measures the ratio of total income received by the 20% of the population with the highest income (top quintile) to that received by the 20% of the population with the lowest income (lowest quintile); Public Wealth Index (PWI) (it divides a nation's economic wealth by its level of social cohesion)	Europe	Strong inverse relationship between PWI scores and TB rates

(7) (Arinaminpathy, 2010)	To study the relationship between lost economic productivity and excess TB cases and mortality	GDP (as a measure of macro-economic conditions)	World	Strong linear associations between lost economic productivity over the period of recession for each country and excess numbers of TB cases and deaths over the same period
(8) (Ploubidis, 2012)	To investigate the prospective association between baseline (measured in 2000) and a nation's wealth, level of egalitarianism, migration rate, health-related lifestyle and social capital with TB incidence and prevalence over a 10-year period (2000-2009)	Smoking as proxy measure of health-related lifestyle, Gini coefficient as a measure of social inequality; logged GDP per capita used as a measure for the standard of living; social trust index used as an indicator of social capital	Europe	Negative prospective association between logged domestic product and TB rates, and a positive prospective association between income inequality and TB
(9) (Oxlade, 2009)	To estimate the association between TB trends over the period 1990-2005 and changes in general health and health services, economic indicators, HIV infection and TB treatment over the same period	GDP, Gini Index	World	Improvements in population health are associated with improvements in TB outcomes. HIV prevalence is associated with TB trends; TB programme performance is not associated with TB incidence in countries with high HIV prevalence
(10) (Oxlade, 2012)	To investigate the mechanism by which poverty increases the risk of TB	DHS Wealth Index Factor score as an indicator of household socioeconomic status; proximate risk factors: smoking, tobacco use, indoor air pollution, low BMI, diabetes, alcohol use and HIV	India	People from the poorest quintile in India are at higher risk of self-reported TB than those in the wealthier quintile; almost all known TB risk factors are more common among the Indian poor (apart from Diabetes and HIV)
(11) (Kaseliene, 2011)	To evaluate changes in inequalities in mortality from infectious diseases and TB by educational level among men and women in Lithuania	Educational level, Relative index of inequality	Lithuania	Considerable increase in mortality from infectious disease and especially TB was found among the least educated people from 1989 to 2001. Inequalities in mortality from infectious diseases were greater among men of different educational level than their female counterparts.

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2: Epidemiological impact of distal/upstream determinants of TB: Mathematical modelling studies

Ref	Aim of the Study	Key social/structural determinants/socioeconomic indicators investigated	Mathematical modelling methods/Type and features of the simulation model	Setting	Conclusion(s)
(2) (Reeves, 2015)	To project the potential influence of the economic recession on TB epidemiology in Europe until 2030.	Government expenditure per capita on public health services. GDP and cumulative decline in GDP during the recession period as a measure of the severity of the recession	<u>Dynamic model</u> Authors applied the findings from the preceding econometric models (see Table 1, ref #2) to dynamic mathematical models of TB transmission and mortality. The mathematical models simulated longitudinal TB rates in each country – given the data on case detection observed before, during and after the financial crisis – as well as a counterfactual scenario in which case detection was unaffected by either the recession or the related austerity. SLIR (susceptible-latent-infectious- recovered) model.	Europe	Recession can lead to short-term reductions in the financial support of programmes for TB control. The associated decrease in the detection of TB is projected to result in sustained, long-term rises in TB incidence, prevalence and mortality.

References

Reeves A, Basu S, McKee M, Sandgren A, Stuckler D, Semenza JC. Tuberculosis control and economic recession: longitudinal study of data from 21 European countries, 1991-2012. Bulletin of the World Health Organization. 2015 Jun 1;93(6):369-79. PubMed PMID: 26240458.

3: Epidemiological impact of proximate/downstream determinants of TB: Mathematical modelling studies

Ref	Aim of the Study	Key social/structural determinants/socioeconomic indicators investigated	Mathematical modelling methods/Type and features of the simulation model	Setting	Conclusion(s)
(12) (Andrews, 2015)	To illustrate the role of social mixing in shaping disparities in the distribution of TB, and demonstrate how the concentration of disease risk and transmission among the poor presents challenges and opportunities for TB control	Wealth	<u>Dynamic</u> Deterministic, compartmental model with parallel structure for two wealth groups with varying parameters, contact rates and social mixing	India	TB control efforts may benefit from preferential targeting toward the poor
(13) (Murray, 2011)	To summarise existing evidence linking social, environmental and biological determinants and TB, and review modelling approaches that have been used to estimate their contribution to the TB epidemic	Smoking, indoor air pollution, diabetes mellitus, alcohol, nutritional status, crowding, migration, aging and economic trends	<u>Non-dynamic</u> Population attributable fraction (PAF) model <u>Dynamic</u> Compartmental SLIR (susceptible-latent-infectious- recovered) model	World	Definition of research priorities in both the study of specific determinants and the development of appropriate models to assess the impact of addressing these determinants
(14) (Odone, 2014)	I) To review epidemiological and biological evidence to describe the relationship between TB, diabetes, and nutritional status. II) To review past trends, present burden, and available future global projections for diabetes,	Diabetes, overweight and obesity, undernutrition and food insecurity	<u>Non-dynamic</u> Analytical model to estimate the effect of diabetes and undernutrition on TB incidence per person per year in different age groups, WHO regions, and over time in various scenarios	World	Reduction of undernutrition and better prevention and care for diabetes combined with improved access to prevention of infection, quality diagnosis, and treatment for all people with TB, could produce a large preventive effect on TB and is crucial to reach the post-2015 TB targets

	<p>overweight and obesity, as well as undernutrition and food insecurity.</p> <p>III) To estimate how different scenarios of future trends for diabetes and undernutrition could affect TB epidemiology until 2035</p>				
(15) (Lin, 2008)	To predict the effects of risk-factors trends on COPD, lung cancer and TB	Smoking, solid fuel use	<p><u>Dynamic</u></p> <p>Dynamic TB transmission model: deterministic compartmental susceptible-latent-infectious-recovered model</p>	China	Reducing smoking and solid-fuel use can substantially reduce predictions of COPD and lung cancer burden and would contribute to effective TB control in China (even when DOTS implementation is less effective)
(16) (Oxlade, 2015)	To project future trends in TB related outcomes under different scenarios for reducing under-nutrition in the adult population in the Central Eastern states of India	Under-nutrition	<p><u>Dynamic</u></p> <p>Compartmental TB transmission model stratified by body mass index parameterised using national and regional data from India (model population is stratified into four exposure levels defined by the mean BMI for each quartile)</p>	India	Intervening on under-nutrition could have a substantial impact on TB incidence and mortality in areas with high prevalence of under nutrition

(17) (Dye, 2011)	To explore the consequences for TB epidemiology and control of changes in BMI, diabetes, population age structure and urbanization in India and Korea	BMI, diabetes, population age structure and urbanization	<u>Non-dynamic</u> Analytical model	India, Republic of Korea	The combination of nutritional and demographic changes operating over the decade from 1998 tended to increase TB incidence per capita in high-burden India and reduce it in lower-burden Korea.
(18) (Ackley, 2015)	To explore the population-level effects of malnutrition and genetic heterogeneity in TB susceptibility on TB epidemics	Malnutrition, genetic heterogeneity	<u>Dynamic</u> Dynamic TB transmission model: deterministic compartmental susceptible-latent-infectious-recovered model	First Nations community in Canada	I) Changes in a population's nutritional status can have significant effects on TB dynamics II) Inclusion of heterogeneity in susceptibility to <i>M.tb</i> infection or risk of TB disease yields improved fit to data
(19) (Childs, 2015)	To describe some of the unifying challenges that arise in modelling malaria, HIV, and TB, including variation in dynamics within the host, diversity in the pathogen, and heterogeneity in human contact networks and behaviour	n/a	Commentary	n/a	Valid parameterisation of models is challenging due to lack of granularity in incidence/prevalence of data

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Ackley, S. F., et al. (2015). "Modeling historical tuberculosis epidemics among Canadian First Nations: effects of malnutrition and genetic variation." PeerJ 3: e1237.

Childs, L. M., et al. (2015). "Modelling challenges in context: Lessons from malaria, HIV, and tuberculosis." Epidemics 10(0): 102-107.

4: Epidemiological impact of proximate/downstream determinants of TB: Statistical analyses

Ref	Aim of the Study	Key social/structural determinants/socioeconomic indicators investigated	Setting	Conclusion(s)
(20) (Santos, 2007)	To assess the influence of socioeconomic status on TB morbidity	Socioeconomic status (incl. level of education, occupational status, income)	Brazil	The pattern of TB morbidity in the population of São José do Rio Preto is influenced by its living conditions.
(21) (Stuckler, 2008)	To evaluate whether the rapid growth of the prison population, can in part account for the divergence in TB incidence and MDR TB prevalence among transition countries, using longitudinal data from 1991 to 2002	Incarceration	Eastern European and Central Asian countries	I) Rate of growth of the prison population (more than the overall size of the prison population) critically relates to variations in TB II) Higher HIV prevalence exacerbates the effect of incarceration on TB incidence

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5: Non-TB mathematical modelling studies: Epidemiological impact of social determinants of health

Ref	Aim of the Study	Key social/structural determinants/socioeconomic indicators investigated	Mathematical modelling methods/Type and features of the simulation model	Setting	Conclusion(s)
(22) (Shannon, 2015)	<p>To review available published data for HIV prevalence and incidence, condom use, and structural determinants among female sex workers (FSWs);</p> <p>To explore the potential effect of structural determinants on the course of epidemics using a deterministic transmission model to simulate potential HIV infections averted through structural changes in regions with concentrated and generalised epidemics, and high HIV prevalence among FSWS.</p>	<p>Macrostructural factors (e.g. law or policy changes), community organisation (e.g. sex worker collectives or sex worker-led outreach), and intersecting social, physical, and policy features of the work environment (e.g. safe vs. unsafe work environments, time-varying exposure to police harassment, physical and sexual violence, and scale-up of ART coverage)</p>	<p>Deterministic transmission dynamic model</p>	<p>Kenya, Canada</p>	<p>Multipronged structural and community-led interventions, alongside biomedical interventions, that substantially reduce HIV burden and promote human rights for sex workers worldwide are needed</p>

<p>(23) (Deering, 2008)</p>	<p>To assess the extent to which migration could explain heterogeneity in HIV prevalence in Bagalkot district, in Karnataka state, India, examining important migration-related risk factors for HIV transmission and implications for prevention</p>	<p>Mobility and migration</p>	<p>Deterministic compartmental mathematical model of heterosexually transmitted HIV infection</p>	<p>India</p>	<p>Impact of different seasonal migration patterns on HIV prevalence in the study setting varied substantially across scenarios</p>
<p>(24) (Alam, 2006)</p>	<p>To investigate the social impact of HIV/AIDS</p>	<p>Household income</p>	<p>Agent-based simulation model</p>	<p>South Africa</p>	<p>Agent-based social simulation model adopted to simulate the complex impact of HIV/AIDS on social networks in rural South Africa is feasible and promising</p>
<p>(25) (Mushayabasa, 2011)</p>	<p>To investigate the effects of socioeconomic status on the transmission dynamics of HIV/AIDS</p>	<p>Socioeconomic status</p>	<p>Deterministic model (two "layers" - rich/poor; eight classes according to disease status)</p>	<p>n/a</p>	<p>Risky sexual behaviour of individuals who are on antiretroviral therapy will increase HIV prevalence in the community. If poor individuals indulge in risky sexual behaviour due to social marginalisation or to procure food for themselves and their children, then HIV/AIDS will remain a public health burden</p>

(26) (Speybroeck, 2013)	To explore how simulation models were used in the field of socioeconomic inequalities in health	Nutritional status, disease, mortality, life expectancy, preterm birth; unequal access to health care (health facilities, treatment or prevention); environmental exposition, health behaviour	Agent-based simulation model	World	Use of simulation models may enhance the understanding and debate about existing and new socioeconomic inequalities of health frameworks. ABM is likely the most suitable tool for studying a complex health inequality situation
(27) (Mahamoud, 2013)	To develop a system dynamics simulation model addressing the complex web of social determinants that shape the health of populations and influence health disparities	Unhealthy behaviour/obese, Chronic illness, Access to health care, Disability, Adverse housing, Social cohesion, Low-income, Mortality rate	Dynamic transmission model (Wellesley Urban Health Model), which simulates changes in health, social determinants, and disparities from 2006 and projects forward to 2046	Canada	The WUHM suggests that income is a substantial driver of health outcomes, having a large impact on both chronic illness and disability prevalence in the population both in the short- and long-term. In terms of strength of influence on health outcomes in the model, income is followed by social cohesion.

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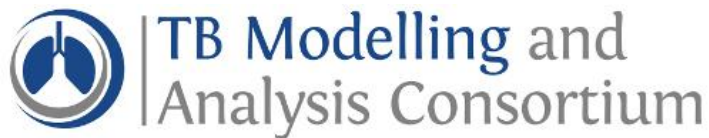
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Appendix 2.2 Agenda and Participant List



Note: Internet passcode - TBMAC2015 (is case sensitive)

TB MAC 7: Modelling socio-economic determinants and interventions for TB - what do we know, where do we go?

13-14 October 2015, Crowne Plaza Times Square Manhattan Hotel, New York, USA

Aim and objectives

Aim: set out path towards including socio-economic trends and interventions into mathematical models of TB

Objective 1: Develop work outlines to incorporate in distal and proximal socio-economic indicators in epidemiological models of TB

Objective 2: Articulate landscape of including socio-economic interventions into multi-intervention evaluations through 2 main topics

2.1: Social transfer programmes

2.2: Co-financing: Costing of TB specific versus general socio-economic interventions

Pre Meeting

1. Review of literature
2. Pre-reading pack developed and sent before meeting (<https://goo.gl/uF9HjG>)

Day 1: What do we know?

(Main room 501/502)

0930-0940: Welcome + TB MAC (past and future) (Richard White - LSHTM)

0940-1000: Intro to meeting (Rein Houben - LSHTM)

Session 1: Wider context of socio-economics and TB

1000-1030: OBJ 1+2: Socio-economics determinants and TB (Knut Lönnroth - GTB)

1030-1100: OBJ 2.1: The global landscape of social transfer programmes for health (Nicole Fraser-Hurt - World Bank)

Coffee break 1100-1130 (room 504)

1130-1200: OBJ 2.2: Principles of co-financing of socio-economic interventions (Anna Vassall and Michelle Remme - LSHTM)

1200-1230: OBJ 2.2: Application of co-financing in countries (Douglas Webb - UNDP)

1230 - 1330: Discussion panel: Is TB different? (Delia Boccia, Jason Madan, Philip Eckhoff) 5 min presentation, followed by open discussion.

Lunch 1330 - 1430 (room 504)

Session 2: Epidemiological modelling of socio-economic factors in TB

Short presentations (all key papers are in reading pack <https://goo.gl/uF9HjG>)

1430 - 1445: Andrew Siroka: lessons from macroeconomic indicators and TB

1445 - 1500: Aaron Reeves: lessons from macroeconomic indicators and TB

1500 - 1515: Jason Andrews: lessons from heterogeneous socio-economic mixing and TB modelling

1515 - 1530: Olivia Oxlade: lessons from downstream socio-economic factors and TB modelling

Coffee break: 1530-1600 (room 504)

1600 - 1715: Discussion panel: *Next steps for TB Epi modelling and socio-economic determinants* (Ted Cohen, David Dowdy, Hoa Nguyen) 5 minute presentations, followed by open discussion.

1715 - 1730: Introduction workshops Day 2 (Rein Houben - LSHTM)

Dinner

Tony's Di Napoli restaurant - Casablanca Hotel, 147 W 43rd Street, NY 10036. **Dinner starts at 1930** (Meet at Crowne Plaza reception at 1915)

Day 2: Where do we go?

(Breakout rooms 509 and 510, main room 501/502)

Focus on Objective 1: Develop work outlines to incorporate in distal and proximal socio-economic indicators in epidemiological models of TB

0930-1000: PLENARY Recap of day 1, objectives day 2 and division into working groups (Rein Houben - LSHTM)

1000-1115: WORKING GROUPS Idea generation, 4 ideas max, prepare 2 sentence summary for plenary discussion

Coffee break 1115 - 1145 (room 504)

1145-1230: PLENARY: Presentation of ideas by each group + feedback + vote

Main room 501/502

1230-1330: WORKING GROUPS: Refinement of work outlines. Deliverable is 2 outlines

Breakout rooms

Expand idea to include:

- Background: - what is the gap
 - what is the advance in the field?

- what is the link to TB policy/practice?

- Aim
- Objectives (tasks to be completed)
- Deliverables
- Profile of team (including suggested partner in global south, or characteristics of partner)
- Suggested budget
- Suggested timeline
- Name(s) who could help refine outline

Lunch 1330-1430 (room 504)

1430-1530: PLENARY presentation of outline and clarifications.

1530-1540: PLENARY Vote for proposals.

Coffee break 1540-1610 (room 504)

1610-1625: PLENARY Presentation of voting results, next steps for funding (Rein Houben - LSHTM)

1625-1630: Thanks and Close

Post meeting.

1. Assigned funding for proposal development and research (total funding available is \$200k, grants must be awarded by Dec 2015, projects close by Dec 2016).
2. Peer-reviewed paper that reports on reviews, presentations and outcomes of meeting discussions.

List of participants

Jason	Andrews	Stanford University	Michelle	Remme	LSHTM
Delia	Boccia	LSHTM	Carlos	Riumallo-Herl	Harvard University
Stewart	Chang	IDM	Andrew	Siroka	WHO
David	Collier	White Ox	Roy	Small	UNDP
Pete	Dodd	University of Sheffield	Hojoon	Sohn	McGill University
Nicole	Fraser-Hurt	World Bank	Sedona	Sweeney	LSHTM
Ivor	Langley	Liverpool University	Douglas	Webb	UNDP
Hsien-Ho	Lin	National University of Taiwan	TB MAC Committee		
Knut	Lonnroth	WHO	Christina	Albertsen	LSHTM
Jason	Madan	University of Warwick	Ted	Cohen	Yale University
Shelly	Malhotra	TB Alliance	David	Dowdy	Johns Hopkins
Emma	McBryde	James Cook University	Philip	Eckhoff	Intellectual Ventures
Hoa	Nguyen	NTP Viet Nam	Rein	Houben	LSHTM
Olivia	Oxlade	McGill University	Michael	Kimerling	KNCV
Debora	Pedrazzoli	LSHTM	Anna	Vassall	LSHTM
Aaron	Reeves	University of Oxford	Richard	White	LSHTM

Appendix 2.3 Potential ideas for the TB MAC RfA call – full list

Potential ideas for the TB MAC RfA call ‘Funding opportunities for projects on structural and socio-economic determinants of TB’

These ideas were generated by participants from a meeting held by TB-MAC on this subject, 13-14 October in New York, USA

Title	Optimising health service organisation and social protection to improve clinical and economic TB outcomes
What is gap	Evidence is lacking on the relationship between diagnostic and treatment system organisation and patient economic burdens and need for social protection.
Advance in field	1)Data mapping 2)Creating the evidence base for health systems and social protection interventions 3)Estimating requirements for SP programmes and decentralisation of services to optimise resource allocation
Link to TB policy/practice	Inform decisions around social protection resource allocation and organisation of services
Title	<i>The impact of TB on household and community impoverishment</i>
What is gap	The SDGs call for a reduction in poverty which is thought to be tied to TB. However, little is known about the social and economic impact of TB at household and community levels. Further, how impoverishment then feeds back into TB transmission is unknown.
Advance in field	Adding a broader understanding of household and community poverty and TB dynamics
Link to TB policy/practice	This would strengthen the rationale for investment for social protection and identify better targets and interventions.
Title	<i>Understanding data and mechanisms of TB control through social protection</i>
What is gap	There is evidence that social protection can improve health outcomes, but there is limited evidence on the mechanisms/pathways through which they affect TB outcomes. These data have not been consolidated in a way that would inform mechanistic models, nor do we understand the mechanisms by which they influence TB outcomes.
Advance in field	Conceptual framework grounded in empirical data could crystallize thinking regarding the mechanisms by which social protection might impact TB outcomes and way in which mechanistic models could incorporate the evidence/data being collected. By using modelling, this work could avoid the operational barriers of complex, expensive experiments/ trials.
Link to TB policy/practice	Social protection is now a non-negotiable component of the global TB strategy for the post-2015 agenda. Need to inform/support this policy drive.

Title	<i>Linking measurable outcomes of social protection programmes to TB impact</i>
What is gap	The effects of social protection programmes are traditionally measured for intermediate outcomes, and the effect of those on TB outcomes remain uncertain.
Advance in field	Translate measurable indicators of social protection (and other socio-economic interventions) into projects of impact on TB outcomes
Link to TB policy/practice	Social protection is now a non-negotiable component of the global TB strategy for the post-2015 agenda. Need to inform/support this policy drive.
Title	<i>The impact of TB on household and community impoverishment</i>
What is gap	The SDGs call for a reduction in poverty which is thought to be tied to TB. However, little is known about the social and economic impact of TB at household and community levels. Further, how impoverishment then feeds back into TB transmission is unknown.
Advance in field	Adding a broader understanding of household and community poverty and TB dynamics
Link to TB policy/practice	This would strengthen the rationale for investment for social protection and identify better targets and interventions.
Title	<i>How do demographic changes impact TB?</i>
What is gap	We don't know: 1) How demographic changes (e.g. urbanisation, geography, migration, displacement, household structure changes) affect TB transmission 2) What proportion of changes in TB are mediated by these factors?
Advance in field	1)Data collation 2)Inform model choice and structure 3)Inform parameterisation of mechanistic model
Link to TB policy/practice	Inform TB control by improving projections of interventions impact and resources allocation
Title	<i>Comparing financial and economic impact of different priorities for TB interventions</i>
What is gap	Beyond the standard set of TB interventions, there are questions as to what to do next with additional funding. One standard tradeoff question is whether to invest in improved social protection of patients currently under care (along with their households) or to invest in intensified case finding activities, such as systematic screening in high risk group/communities.
Advance in field	Data on costs to patients and household is available in many countries, and new patient costs surveys are being planning in several countries. There are some data on the impact of social protection and financial/social enablers on access and adherence.

	<p>A systematic review has been done on the impact of systematic screening on case detection and epidemiological parameters However, empirical data on impact of social protection or systematic screening on financial risk protection are scarce.</p>
<p>Link to TB policy/practice</p>	<p>Move beyond zero-sum game (improve financial outcomes versus improve epidemiological outcomes) to see epidemiological impacts of improved social protection of patients. Provide context-specific projections for informing this policy tradeoff.</p>