Umoya omuhle

Infection prevention and control for tuberculosis in South Africa in the era of decentralised care: A whole systems approach

Preliminary results | March 2021

Background, rationale, and approach

Health care workers are at high risk of tuberculosis (TB) and health facilities are neglected sites of *Mycobacterium tuberculosis* (*Mtb)* transmission. There is a gap between TB infection prevention and control (IPC) guidelines and implementation.

We examined the social, biological, and infrastructural dynamics of *Mtb* transmission in 12 primary health care clinics in two provinces of South Africa, and aimed to develop and model health systems interventions to improve TB IPC.

Our approach was comparative, contextual, and inter-disciplinary.

We studied six clinics in Western Cape and six in KwaZulu-Natal. We triangulated methods, perspectives, and data to situate TB IPC policies, processes, and practices at clinic level, within the structure of the whole system. We viewed interventions as 'complex', each including multiple, interacting components that required tailoring to setting.

A. Setting the context

	Macro: the policy landscape	Micro: the clinic waiting area
Methods	Interviews with 15 policy actors (health system, researchers, activists) at various levels of the health system, from local clinics to global policymaking bodies.	1. Structured and unstructured observations; 2. Formal interviews and informal conversations with clinic managers, health care workers, and patients; 3. Patient flow mapping
Key findings	TB IPC has become "everybody's business and nobody's business": there was an institutional fragmentation of TB IPC ownership and a persistent conceptual ambiguity around 'what TB IPC is' and where it belongs within the broader health system. There was a perceived general lack of TB activism or civil society mobilisation to address TB concerns; a lack of cost/effectiveness evidence for TB IPC interventions was not seen as a direct problem; and TB programmes were described as institutionalised and routinised. The highest risk was perceived to be from contact with people taking TB treatment, rather than with people with undiagnosed TB. TB IPC was seen as a problem that cannot be solved (only) by individuals or by national government. [Read the peer-reviewed article]	We observed long waiting times and overcrowding, with possible extended exposure to people with active TB, exacerbated by poor ventilation, no cough triaging, no respiratory separation, no evidence of respiratory hygiene, and poor use of PPE. The system challenges manifested in the main waiting areas included: insufficient technical expertise for policy translation to the local context; hierarchical organisational structure, based on the issuing of directives requiring compliance; poor differentiation of management roles within and between system levels; poor team synergies, with tensions between professional categories, managers and workers, races, and staff and patients. All of the above limited innovation & adaptive learning capacity. [Read the abstract - page 550]

B. Assessing the drivers of *Mtb* transmission in clinics

	Epidemiology	Ventilation, congregation, and infrastructure
Methods	A survey in two KZN clinics to estimate the prevalence of *Mtb* in sputum among adult clinic attendees	1. Measurement of CO_2 levels to estimate ventilation in key spaces 2. Modified waiting time surveys to estimate how long and where attendees waited 3. Interviews with health facility personnel and built environment specialists
Key findings	Of 2,055 adults enrolled, 20 (1%) had *Mtb* in their sputum Most clinic attendees with *Mtb* in sputum were asymptomatic (70%); symptom-based screening may miss many people with active TB. The clinic-based prevalence estimate was slightly higher than the estimated prevalence of TB in the rural community surrounding the clinics (1% vs. 0.6%) [Read the abstract – page 371]	There was substantial variation in the rate of natural ventilation: smaller spaces were generally less well ventilated. Opening windows and doors led to meaningful improvements in ventilation in almost all spaces. Almost half of attendees had arrived before 09h00; the odds of spending ≥3 hours at clinic were higher for these individuals than for those who arrived after 09h00. Attendees spent less time indoors if they were attending a clinic that used an outdoor waiting area as part of the patient pathway, compared with those who attended clinics that did not have an outdoor waiting area or did not include one in the patient pathway. Building design and structural changes are often outside the control of those in charge of clinics, and ventilation requirements are sometimes perceived to be at odds with climatic conditions. Changes can have wide-ranging effects: care pathways are subject to changes in disease priorities and health policy and optimal arrangements for managing patient load and flow are subject to clinic infrastructure and the organisation of care. Points of disjuncture and tension can lead to bottlenecks and unintended lengthening of waits.

Please consider all findings provisional. Published articles and conference abstracts are available here.

C. Bringing the data together to design, model, and cost interventions

Step 1: System dynamics modelling (SDM)

We held two participatory workshops that involved a wide range of stakeholders; the data presented on page 1 were fed into workshops. Workshop participants created maps of the system and identified three key dynamics: **1.** high utilisation creates bottlenecks, which affect crowding and transmission; **2.** high utilisation and competing programme demands erode staff wellbeing and help create a compliant clinic culture; and **3.** context- and implementation-informed IPC guideline development relies on policymaking learning more from existing data and experiences.

Interventions focused on three areas:
1) improving ventilation and safety; **2)** wearing protective equipment; & **3)** reducing numbers of people in indoor spaces.
Workshop participants noted that interventions should also consider staff workload; challenges to morale; the overarching organisational culture; consultation processes to ensure buy-in at different system levels; mechanisms to integrate with other systems; and measures to improve the effectiveness of training and supervision.

	1	2	3	4	5	6	7
Seven identified interventions and their mechanisms	Improving ventilation by opening doors and windows	Improving ventilation by installing simple retrofits	Installing UVGI lights	Surgical masks for patients & N95 respirators for staff	Curbing high utilisation by strengthening CCMDD	Reducing crowding via a queue management system	Reducing waiting times via an appointment system
Selected core shared elements*	Patient surveys to monitor satisfaction & potential issues						
	Training: Office of Health Standards Compliance; peer-reviewers; managers			*Per interventions 1 & 2*		Training: Office of Health Standards Compliance; peer-reviewers; managers Staff/community workshops	
	M&E; communication campaigns						
Specific elements	Community workshops	One-off workshop	Install UVGI	Community workshops	Maximise usage; revise guidelines	Install queueing system	Install appt system

**Not comprehensive. appt: appointment; CCMDD: Central Chronic Medicine Dispensing and Distribution Programme; UVGI: ultraviolet germicidal irradiation*

Step 2: Mathematical modelling

We constructed two individual-based models to estimate the effectiveness of the proposed interventions

Model 1. Within clinics transmission: *"What proportion of Mtb transmission to patients in clinics could be prevented by the proposed interventions?"*

The model tracks the location of each patient and the number of patients in each waiting area over time, uses ventilation estimates and the Wells-Riley approach to estimate transmission risk, and simulates the seven interventions individually.

Key result: IPC interventions could reduce transmission to patients by 22%–83%. Queue management + outdoor waiting areas has the largest impact; UVGI in waiting areas is almost as impactful and may be more feasible in some clinics.

Model 2. Community transmission: *"What proportion of TB results from transmission in clinics, and what are the effects of the interventions on community TB incidence?"*

A model of the population of two clinic catchment areas. TB is drug susceptible or multidrug-resistant; individuals are HIV negative, HIV positive on antiretroviral therapy (ART), or HIV positive not on ART. A complex contact and transmission structure models contact patterns in various settings.

Key result: Overall, 4%–14% of disease was from transmission in clinics in 2019 (higher in HIV-positive than HIV-negative people). Implementing IPC interventions in clinics reduces the number of people developing TB in 2021–30 by 3%–8%.

Step 3: Cost modelling

The costing framework was developed alongside system dynamics modelling (SDM), recognising that 1) the key to several interventions is behaviour change; 2) many of these interventions are already implemented in some form; and 3) current implementation is suboptimal and costing 'business as usual' activities is not going to achieve intended effectiveness targets. Therefore, enablers were identified with experts and practitioners during SDM workshops and the package of interventions and enablers included in economic analysis reflects the full opportunity cost of achieving reductions in TB transmission in clinics.

Note that there were some areas that were not amenable to traditional costing methods: it was difficult to identify inputs that could be priced and quantified (bottom-up) and difficult to allocate expenditure across service level activities (top-down).

Key result: All interventions were highly cost-effective
(South Africa considers interventions that cost ~US$3,200 per DALY averted to be cost-effective).

For further information please visit https://www.lshtm.ac.uk/research/centres-projects-groups/uo

Publications and conference abstracts are available at
https://www.lshtm.ac.uk/research/centres-projects-groups/uo#publications

ACKNOWLEDGMENTS

Our thanks to the nearly 7,000 people who participated in the study (patients, clinic visitors, health care workers, policymakers and other government staff, engineers, architects, activists, researchers); the managers and staff at the 12 participating clinics; participants at System Dynamics and Patient Flow workshops; colleagues in Western Cape Department of Health; the project oversight group; and ethics committees at LSHTM, UCT, UKZN, and QMU.

Umoya omuhle researchers

Investigators and core team

Kathy Baisley, Peter Beckwith, Fiammetta Bozzani, Adrienne Burrough, Chris Colvin, Karin Diaconu, Indira Govender, Alison Grant, Idriss Kallon, Aaron Karat, Karina Kielmann, Hayley MacGregor, Nicky McCreesh, Janet Seeley, Alison Swartz, Amy Thomas, Anna Vassall, Anna Voce, Richard White, Tom Yates, Gimenne Zwama

Africa Health Research Institute

Nkosingiphile Buthelezi, Njabulo Dayi, Siphephelo Dlamini, Yutu Dlamini, Raveshni Durgiah, Anita Edwards, Dickman Gareta, Patrick Gabela, Harriet Gliddon, Emmerencia Gumede, Sashin Harilall, Kobus Herbst, Hannah Keal, Mandla Khoza, Nozi Khumalo, Zilethile Khumalo, Nondumiso Kumalo, Richard Lessells, Sithembiso Luthuli, Sinethemba Mabuyakhulu, Nonhlanhla Madlopha, Tacha Malaza, Sanele Mbuyazi, Simphiwe Mdluli, Thabile Mkhize, Duduzile Mkhwanazi, Zinhle Mkhwanazi, Zodwa Mkhwanazi, Tshwaraganang Modise, Sashen Moodley, Sihle Mthethwa, Xolile Mpofana, Sphiwe Mthethwa, Nozipho Mthethwa, Silindile Mthembu, Sanele Mthiyane, Vanisha Munsamy, Thomas Murray, Senzile Myeni, Tevania Naidoo, Nompilo Ndlela, Zama Ndlela, Thandekile Nene, Phumla Ngcobo, Nzuzo Ntombela, Sabelo Ntuli, Nompumulelo Nyawo, Stephen Olivier, Anand Ramnanan, Aruna Sevakram, Sizwe Sikhakane, Zizile Sikhosana, Theresa Smit, Marlise Venter, Emily Wong, Precious Zulu

University of KwaZulu-Natal

Bavashni Govender, Zama Khanyile, Nokuthula Lushaba, Nonhlanhla Maphumulo, Sharmila Rugbeer, Thandeka Smith

University of Cape Town

Amy Burdzik, Ruvimbo Chigwanda, Suzanne Key, Aphiwe Makalima, Godfrey Manuel, Phumzile Nywagi, Anathi Mngxekeza, Awethu Gawulekapa, Precious Mathenjwa, Samantha Moyo, Seonaid Kabiah, Sinead Murphy, Siphokazi Adonisi, Siphosethu Titise, Tamia Jansen, Yolanda Qeja

Queen Margaret University

Jenny Falconer, Kitty Flynn, Claire McLellan

London School of Hygiene & Tropical Medicine

Arminder Deol, Naomi Stewart

Project oversight group

Thilo Govender, Graeme Meintjes, Vanessa Mudaly, Lindiwe Mvusi, Jacqui Ngozo, Helen Schneider

Funders

E·S·R·C Economic & Social Research Council; GCRF Global Challenges Research Fund; AMR Tackling Antimicrobial Resistance, a cross council initiative; The Bloomsbury SET Science | Economics | Technology

Host institutions

University of KwaZulu-Natal / Inyuvesi Yakwazulu-Natali; University of Cape Town; Africa Health Research Institute; London School of Hygiene & Tropical Medicine; Imperial College London; IDS Institute of Development Studies; Queen Margaret University Institute for Global Health and Development