Title
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Correspondence: New conceptual framework for tuberculosis transmission

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Abstract

A new conceptual framework for understanding and modeling tuberculosis transmission in HIV-endemic settings

We read with interest the recent Comment by Dr. Sekkides[1], and the accompanying articles, on the necessity of attaining a greater understanding of tuberculosis transmission dynamics in order to design more effective control strategies. This need is particularly acute in HIV-endemic settings where many individuals are co-infected with both pathogens.

In sub-Saharan Africa (SSA), populations are extremely mobile; this increases the complexity of the transmission dynamics of infectious diseases. We propose a new conceptual framework (that includes mobility) for understanding, and modeling, tuberculosis transmission in SSA. Our framework includes three transmission pathways: (i) resident-to-resident transmission (individuals acquire tuberculosis in their home community from other residents), (ii) visitor-caused transmission (individuals acquire tuberculosis in their home community from a resident of another community), and (iii) travel-related transmission (individuals acquire tuberculosis in another community). Within this framework, a country-level epidemic is conceptualized as a series of mobility-linked micro-epidemics.

The importance of each pathway can be determined by constructing country-level maps of HIV and tuberculosis, and identifying large-scale mobility networks. This requires detailed spatial epidemiologic data on HIV and tuberculosis, and population-level mobility data. Many countries in SSA have HIV-testing data that can be used to map their epidemic; as an example, data from Malawi (figure A) are shown (figure B). Data needed to map tuberculosis epidemics exist for some countries in SSA. However, mobility data are extremely scarce; travel data reveal spatial patterns (figure C), but not networks. Mobility networks can be identified by analyzing large datasets of call detail records from mobile phones[2]. This approach has been used to determine the importance of visitor-caused, and

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Contributors

JTO and SB developed the concept and wrote the manuscript, JTO made the figure.

Declaration of interests

JTO and SB declare that they have no conflicts of interest.

travel-related, transmission of malaria[3]. Applying this approach to tuberculosis could result in a greater understanding of transmission.

As Sekkides and colleagues discuss, mathematical models are used to predict the impact of tuberculosis control strategies. We believe that there is a need to develop a new generation of models that include mobility-driven transmission; current tuberculosis models are based on models developed by Blower and colleagues[4,5] almost 25 years ago. These new models should include visitor-caused and travel-related transmission pathways, and realistic representations of large-scale mobility networks. We predict that these more realistic models will show that reducing transmission in a hot spot (an area of high transmission), without also preventing visitor-caused and travel-related transmission, is an ineffective control strategy. More importantly, we predict that modeling mobility-driven transmission will lead to the design of more effective tuberculosis control strategies.

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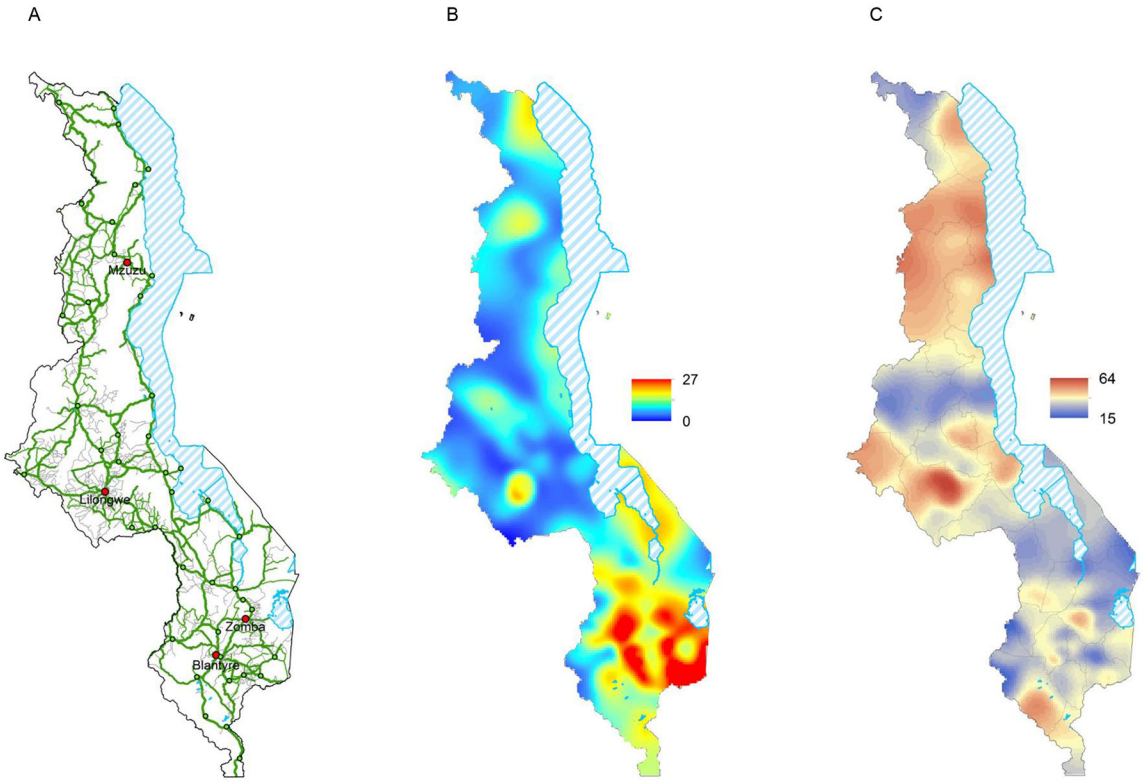

Figure: HIV prevalence and mobility maps for Malawi.

Figure: (A) Map of Malawi's road network and cities. Main roads are shown in green, residential roads in gray. Towns are denoted with green circles, major cities with red circles, and lakes by striped blue regions. **(B)** HIV epidemic map, constructed from HIV-testing data, showing the geographic variation in prevalence (%) in 15–49 year olds. **(C)** Mobility map showing the percentage of 15–49 year olds who made one or more overnight trips in the past 12 months. Data used to construct (B) and (C) are from the 2015–16 Malawi Demographic and Health Survey.