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Strengthening Tuberculosis Control Overseas: Who Benefits?

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A B S T R A C T

Background: Although tuberculosis is a major cause of morbidity and mortality worldwide, available funding falls far short of that required for effective control. Economic and spillover consequences of investments in the treatment of tuberculosis are unclear, particularly when steep gradients in the disease and response are linked by population movements, such as that between Papua New Guinea (PNG) and the Australian cross-border region. **Objective:** To undertake an economic evaluation of Australian support for the expansion of basic Directly Observed Treatment, Short Course in the PNG border area of the South Fly from the current level of 14% coverage. **Methods:** Both cost-utility analysis and cost-benefit analysis were applied to models that allow for population movement across regions with different characteristics of tuberculosis burden, transmission, and access to treatment. Cost-benefit data were drawn primarily from estimates published by the World Health Organization, and disease transmission data were drawn from a previously published model. **Results:** Investing $16 million to increase basic Directly Observed Treatment, Short Course coverage in the South Fly generates a net present value of roughly $74 million for Australia (discounted 2005 dollars). The cost per disability-adjusted life-year averted and quality-adjusted life-year saved for PNG is $7 and $4.6, respectively. **Conclusions:** Where regions with major disparities in tuberculosis burden and health system resourcing are connected through population movements, investments in tuberculosis control are of mutual benefit, resulting in net health and economic gains on both sides of the border. These findings are likely to inform the case for appropriate investment in tuberculosis control globally.

Keywords: Australia, cost-benefit analysis, cost-utility analysis, DOTS, metapopulation model, PNG, tuberculosis control.

Introduction

Tuberculosis (TB) remains a major health threat, being the second leading cause of death from an infectious disease worldwide. Two decades after the declaration of TB as a global health emergency by the World Health Organization (WHO), in 1993, the financial resources needed in the fight against TB remain enormous [1]. Existing and inadequate funding levels are largely because most of the expenses incurred in the control of TB are funded out of increasingly tight national budgets, while the prevalence of TB is skewed toward poor developing countries who can least afford it [1].

As a long-lived airborne communicable disease, TB takes its toll not only on developing countries where prevalence is high but also on developed countries, partly due to the mobility of the disease. In developed countries, foreign-born immigrants and travelers to areas with a high burden of TB account for an increasing proportion of all new cases of TB [2–5]. That said, measures taken thus far to prevent TB in developed countries are typically confined within given borders to the home country [6–10]. Analysis suggests that strengthening TB programs in countries with a higher burden of TB, where most immigrants and visitors come from, thus reducing the levels of transmission from this source, may generate significant domestic gains for developed countries [11]. Past modeling of such transmission and interventions, however, has not accounted for the impact of citizens from developed countries traveling to high-incidence countries. Therefore, there is a need to develop models that account for the impact of two-way population movements to quantify more accurately the benefits of measures to reduce TB incidence occurring from specific two-way travel between areas with a high and low burden of TB.

We address this gap in the literature by evaluating the Australian-funded control of TB in Papua New Guinea (PNG), its closest neighbor. It is worth noting that Australia has one of the most well-resourced health service systems and the lowest burden of TB in the world, while PNG is a poor developing country with many health system challenges, including a very high burden of TB. Our economic evaluation draws on the perspectives of both the broader society and the health sector.

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We focus only on the neighboring border areas of these two countries, which covers the Torres Strait Islands (TSI) of Australia and the South Fly district of PNG. Here, movements of people between the two communities for traditional activities are frequent and largely unrestricted because of a special treaty signed between the two countries, facilitating cross-border movement for traditional purposes. For this reason, the area is a principal focus for concerns related to ongoing importation of TB from PNG. We consider an Australian-funded expansion of a basic Directly Observed Treatment, Short Course (or basic DOTS) program in the South Fly, which covers detection and treatment of patients with infectious (pulmonary) TB. This intervention is the standard recommended by the WHO, including that for resource-poor areas such as the South Fly where TB prevalence and incidence are high, while the prevailing TB programs and health services in place are particularly weak [12–14].

Methods

We undertook an economic evaluation of Australia's support for the control of TB in PNG based on an epidemiological model that captures the patterns of disease transmission between the two regions. Our evaluation draws on the perspective of both the heath sector and society. That is, we apply a cost-utility analysis (CUA) and a cost-benefit analysis (CBA)—the principal tools used to guide resource allocation in the health sector and the whole economy, respectively—in our evaluation. Being identical in measuring costs, these two approaches differ in the measurement of benefits. In particular, CUA measures health improvements due to an intervention by a combination of duration and the quality of life saved while CBA measures them in monetary terms. As such, CUA allows the comparison of one intervention against another in terms of the health gains it achieves while CBA allows for the comparison of benefits aside from health gains alone. Each has its own advantages, and by using both, we address the limitations in applying only one method.

Interventions and Comparator

The interventions we assess in our article focus on the expansion of the basic DOTS program in PNG's South Fly from the current level of 14% coverage to various levels including 30%, 50%, 65%, 80%, and 95% coverage. These interventions were simulated to last for 20 years, starting from 2014. The duration of 20 years was used because latent infections can last a lifetime, and changes in prevalence due to differences in control are likely to remain after a long duration, such as 20 years. The health outcomes and costs generated by expanding the basic DOTS coverage were calculated in relation to those generated by the comparator, which was to maintain the current 14% coverage. Differences in costs and benefits under the interventions and the comparator served as inputs to our economic evaluation.

We also explored the effect of a delay between detection and treatment. Existing literature on other developing countries suggests that 4 weeks is correct [15]. In the South Fly, however, a delay of 12 weeks seems more realistic because the communities here are relatively isolated and health services are poor [16]. Therefore, we present results with 1) a delay of 12 weeks, as a realistic case for the South Fly; 2) 4 weeks, using an estimate of the average delay in developing countries; and 3) 1 week, a possible ultimate goal for the South Fly. Changes in the delay between detection and treatment were considered in conjunction with changes in the expansion of the basic DOTS coverage because this alteration alone does not yield significant changes in health benefits due to the low coverage of the current basic DOTS program in the South Fly.

Finally, it is worth noting that we consider only the South Fly and the TSI instead of the whole of Australia and PNG in our model because the frequent and relatively unscreened movements between the two countries occur between these two communities because of an existing treaty. This situation makes the region unique and a focus therefore of special concern related to a possible spread of TB from PNG to Australia.

Epidemiological Model

Our epidemiological model was built using a combination of metapopulation and compartment modeling techniques, following Hickson et al. [17]. The former not only allows for each country or subpopulation to have its own dynamics and attributes but also for interaction (albeit limited) between these subpopulations [18–20]. This feature is particularly important to our analysis because there are major disparities in the burden and transmission of TB, as well as access to treatment between the two regions, which exist within the context of physical and cultural proximity, and with the established treaties for population movements in place. There are four subpopulations in the model: 1) Australians in Australia—Pop (1,1); 2) Australians in PNG—Pop (2,1); 3) Papua New Guineans in PNG—Pop (2,2); and 4) Papua New Guineans in Australia—Pop (1,2) (Fig. 1). A compartment technique was used to categorize people in each subpopulation by health state to distinguish uninfected from infected persons, latent infection from active infectious (pulmonary) and noninfectious (extrapulmonary) TB, and those individuals being treated for the first time from those being re-treated after the first treatment failure (Fig. 2).

Transition between health states, interaction of subpopulations due to travel as well as dynamics through time in the model are captured by systems of nonlinear ordinary differential equations provided in the Supplementary Material found at http://dx.doi.org/10.1016/j.jval.2014.11.008. The parameters and their values used in the model reflect the current and historical situation in the two regions. For example, we started running the model with a single infectious case in PNG from the year 1800 until the epidemic stabilized, and the transmission rates were determined so that the incidence, prevalence, death rate, and population match the available data [17]. Based on this run, the initial conditions in terms of distributions of subpopulations across various health states were determined for intervention analysis.

Some assumptions were made when we experimented with the interventions. First, we assumed that the rates of travel undertaken by Australians and Papua New Guinean people, estimated using two-way border crossings reported by the Department of Immigration and Citizenship [21], remained constant throughout the period of analysis. Second, we assumed that the detection rate, which determines the coverage of a basic DOTS program, increased following a logarithmic function to capture the fact that detection is easiest to improve on when it is initially low and becomes increasingly difficult to enhance with

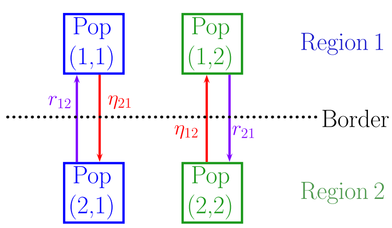

Fig. 1 – Schematic of subpopulations in the metapopulation for South Fly and Torres Strait Islands. Note that homogeneous mixing occurs on each side of the border between Pop(1,1) and Pop(1,2) and between Pop(2,1) and Pop(2,2).