Smoking and Tuberculosis Risk: High Attributable Risk in a Low-Incidence Environment

Justin T Denholm[1,2,*], James M Trauer[1,4] and Emma S McBryde[1,3,4]

[1]*Victorian Tuberculosis Program, Doherty Institute for Infection and Immunity, Melbourne, Victoria*

[2]*Department of Microbiology and Immunology, University of Melbourne, Parkville, Victoria*

[3]*Victorian Infectious Diseases Service, Royal Melbourne Hospital, Parkville, Victoria*

[4]*Burnet Institute, Prahran, Victoria*

Abstract: *Objectives*: To evaluate the potential impact of smoking cessation strategies on TB incidence in Victoria, Australia.

Methods: A previously validated model of TB in migrants was adapted to concentrate on the attributable TB risk arising from smoking. This model included realistic estimates of population smoking rates, and incorporation of risk factors for TB disease such as smoking, HIV and diabetes. A baseline scenario was compared with an alternative scenario in which a hypothetical public health strategy eliminating smoking was introduced.

Outcome measures: The primary outcome was the number of TB cases in the Australian state of Victoria in the year 2050. Secondary outcomes considered were total case burden during the period considered and the population attributable fraction of TB cases related to smoking.

Results: Under the baseline scenario, a median of 318 cases of TB occurred in the target year of 2050, corresponding to an estimated incidence of 3.5 cases/100,000 population. The alternative scenario, where no smoking occurred, found 272 cases (2.95 cases/100,000 population) occurring in 2050; a 14.5% reduction in TB cases. Over the entire period considered, 1650 fewer cases of TB occurred in the alternative scenario, suggesting a population attributable fraction of 11.2% of TB cases from smoking in the Australian context.

Conclusions: Smoking cessation strategies may have disproportionate benefits in TB incidence reduction. Such benefits should be considered in additional to other well-recognised population health effects from smoking reduction.

Keywords: Tuberculosis, smoking, public health, mathematical modeling.

1. INTRODUCTION

The association between tobacco smoking and risk of tuberculosis (TB) disease is a recognized and important connection, particularly in counties with high TB prevalence [1]. While the mechanisms of this association are complex, direct effects of smoking on cellular immunity and structural lung disease are likely to cause significant increase in human susceptibility to TB infection and disease [2]. However, the significance of this association may be less appreciated in lower prevalence countries, where attention is commonly focused on other important effects of smoking such as malignancy and cardiovascular disease [3, 4].

Australia has a relatively low incidence of TB overall, with 6.5 notified cases per 100,000 population in 2012 [5]. As a country identified within the World Health Organization's *Framework Towards TB Elimination*, Australian public health strategies will aim for continued reduction of TB incidence with the ultimate goal of elimination [6]. Further reducing an already low burden of disease in an Australian context will require consideration of a variety of factors leading to active disease, which may include modifiable risk factors such as smoking in addition to traditional TB control-focused approaches.

The risk of TB disease is substantially higher in people born in higher-prevalence countries, many of which also have higher rates of tobacco smoking than Australia [7, 8]. The combination of increased rates of smoking in migrant cohorts and their higher risk of TB has the potential to lead to amplification of the public health impact of tobacco smoking on TB risk in this population. However, little previous work has attempted to quantify the impact of smoking on TB incidence in low-prevalence settings, and the corresponding potential benefit of smoking cessation on TB incidence reduction. We therefore aimed to investigate and quantify this impact through a mathematical modelling approach.

2. METHODS

We adapted a previously validated model of TB in migrants to concentrate on the attributable TB risk

*Address correspondence to this author at the Victorian Tuberculosis Program, Doherty Institute for Infection and Immunity, 792 Elizabeth Street, Melbourne, Victoria, Australia 3000; Tel: +61 3 9342 9428; Fax: +61 3 9342 7277
Email; justin.denholm@mh.org.au

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arising from smoking. Detailed model construction methods have been described elsewhere [9]. Briefly, this was an individual-based model with age- and sex specific smoking rates for regions of origin incorporated in the base model. Additional factors known to influence TB risk, such as HIV and diabetes, were also incorporated into the model. Individuals who smoke tobacco were considered to have roughly twice the risk of progressing to active TB (OR 2.01) [10]. The impact of a previous history of smoking was not considered.

The primary outcome considered in this model was the number of TB cases in the Australian state of Victoria during the period 2013-2050, to coincide with Millennium Development Goal (MDG) target periods. Corresponding incidence was estimated using independent forward projections of population growth. Baseline scenarios were conducted and compared with an alternative scenario where smoking was removed as a modifying factor; in effect simulating a completely effective hypothetical strategy for smoking cessation or smoking ban to quantify the number and proportion of TB cases attributable to smoking.

3. RESULTS

The baseline scenario from this approach found an expected median projection of 14,700 cumulative cases of TB over this period, with 318 cases occurring in the target year of 2050. In 2050, this corresponded to an estimated incidence of 3.5 cases per 100,000 population. Figure **1** shows the baseline scenario as compared with an alternative scenario where no smoking occurs ('smoking ban'). Under the new scenario, a median of 13,050 cumulative cases of TB occurred, with 272 cases occurring in 2050. Estimated incidence in 2050 under this scenario was 2.95 cases per 100,000 population.

In the target year of 2050, the alternative scenario resulted in a 14.5% reduction in TB case numbers. Over the entire period considered, 1650 fewer cases of TB occurred in the alternative scenario, suggesting a population attributable fraction of 11.2% of TB cases from smoking in the Australian context.

4. CONCLUSIONS

This model identified a substantial proportion of TB cases in Australia were attributable to smoking. The level of impact was considerably higher than might have predicted based simply on previously identified individual risk estimates. The doubling of TB risk associated with smoking incorporated into this model was responsible for a population attributable fraction of more than 11% of all TB cases, with the heterogeneity of risk of TB in the Australian population increasing the relative public health impact. The magnitude of this effect may not have been anticipated in public health considerations if the interaction between these factors in migrant cohorts was unrecognized.

Results presented are based on a hypothetical, completely effective smoking ban, and as such are

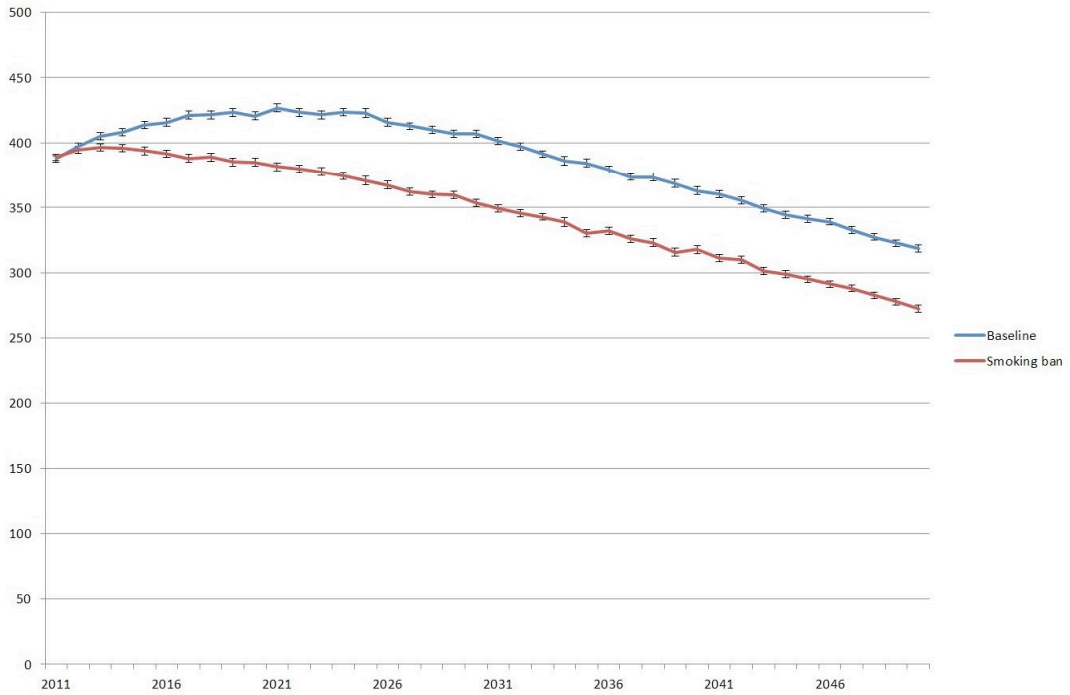

Figure 1: Number of model-predicted cases of tuberculosis in Victoria, Australia; 2011-2050.

clearly idealistic. Nonetheless, we hope that they demonstrate the theoretical benefits of population-level smoking reduction strategies on TB incidence; a further benefit to such strategies over and above other well recognized health-related impacts. While complete elimination of smoking-related risk is an unrealistic short-term aim, this model highlights that the population impact of tobacco smoking reduction on TB incidence may be higher than expected, in light of the cohorts with high rates of both smoking and high TB risk. We would therefore draw attention to the fact that TB incidence reduction is a significant additional benefit arising from tobacco control in populations at risk of TB, even in low-incidence settings, and should be considered as an additional benefit arising from smoking cessation efforts.

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