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# Title

Quantifying the global number of tuberculosis survivors: a modelling study


# Authors

Peter J Dodd[1] PhD
Courtney M Yuen[2,3] PhD
Shamanthi M Jayasooriya[4] PhD
Marieke M van der Zalm[5] PhD
James A Seddon[5,6] PhD

# Affiliations

1. School of Health and Related Research, University of Sheffield, Sheffield, United Kingdom
2. Harvard Medical School, Boston, MA, USA
3. Brigham and Women's Hospital, Boston, MA, USA
4. Academic Unit of Primary Care, University of Sheffield, United Kingdom
5. Desmond Tutu TB Centre, Department of Paediatrics and Child Health, Faculty of Medicine and Health Sciences, Stellenbosch University, Cape Town, South Africa
6. Section of Paediatric Infectious Diseases, Department of Infectious Diseases, Imperial College London, London, United Kingdom



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# Corresponding Author

Peter J Dodd, p.j.dodd@sheffield.ac.uk, School of Health and Related Research, Regent Court, Sheffield, S1 4DA, UK

## Research in Context

*Evidence before this study*

There is increasing recognition that many individuals surviving tuberculosis experience substantial morbidity, are at increased risk of developing tuberculosis again, and have higher all cause mortality than those who have never had tuberculosis. Tuberculosis can also lead to stigma and can impact on the finances of the family beyond the end of treatment. These impacts have been reviewed, including a systematic review and meta-analysis of relative mortality. In order to identify and support these survivors, a first step is to quantify the number alive today that have had tuberculosis.

van Kampen and colleagues undertook a broad systematic scoping review which searched for articles on post-tuberculosis morbidity, published between 1990 and 2018, finding a rapidly accelerating literature in this area. To supplement this therefore, we searched the PubMed from 2018 onwards with the terms: (((cure* OR sequel* OR recovered OR resolved OR former OR "history of" OR survivor* OR prior OR healed OR previous* OR post-treatment OR “completed treatment” OR “after treatment”) AND (tubercul* OR TB)) OR (post-tuberculosis OR posttuberculosis OR posttubercular OR post-tubercular OR post-TB OR treated tubercul* OR “treated pulmonary TB” OR “treated pulmonary tuberculosis” OR “treated tb”)) AND (“burden” OR number OR “life year” OR prevalen* OR estimate*) AND 2018:2020[dp]. This search yielded 2,804 results (8/8/2020). We sifted these search results and the articles included by van Kampen and colleagues for relevance. In 2011, Denning and colleagues used a simple estimation approach to quantify the global burden of chronic pulmonary aspergillosis in tuberculosis survivors over a five year period (and subsequently in 4 particular countries). We found no articles estimating the numbers of tuberculosis survivors around the world, nor the cumulative life years lived after tuberculosis disease.

*Added value of this study*

Our analysis estimates that 363 million people developed tuberculosis between 1980 and 2019, of which 155 million are alive today. A total of 3.5 billion life years were lived in this period by people who had developed tuberculosis. We found that 27 million of these individuals were diagnosed and treated in the last five years, representing a population that is amenable to identification, screening and potential therapeutic intervention. Almost half of those diagnosed in the last five years (12 million) were treated in the South-East Asia World Health Organization region and globally 6% were living with HIV at the time of their tuberculosis diagnosis.

*Implications of all the available evidence*

Tuberculosis programmes have generally focussed on finding and diagnosing cases of tuberculosis and supporting these individuals to the end of treatment. Our data suggest that there is a large population of tuberculosis survivors who are alive today who would benefit from screening for post tuberculosis consequences and then, if necessary medical intervention. Many might also need financial or social support. More research is required in this field to better understand the pathophysiology, spectrum and burden of post-tuberculosis morbidity and to develop improved therapies that might prevent or treat those with impairment.

## Abstract

Background

People who survive tuberculosis continue to experience clinical and societal consequences after recovery, including increased risks of recurrent tuberculosis, premature death, reduced lung function, and ongoing stigma. We aimed to describe the magnitude of this issue by estimating the number of tuberculosis survivors, who could be amenable to intervention.

Methods

We estimated the number of people who developed tuberculosis during 1980-2019 and survived until 2020. Numbers surviving treatment were based on country-level data on tuberculosis case notifications reported to the World Health Organization (WHO), excluding people who died during treatment. Numbers surviving untreated tuberculosis were based on the difference between WHO country-level incidence estimates and notifications, with published age- and HIV-stratified case fatality ratios applied. Post-tuberculosis life tables were developed for each country-year, using United Nations World Population Prospects 2019 mortality rates and published post-tuberculosis mortality hazard ratios.

Findings

Between 1980 and 2019 we estimate that 363 (95% uncertainty interval [UI] 287 - 438) million people developed tuberculosis, of whom 172 (95%UI 169 - 174) million were treated. Individuals who developed tuberculosis since 1980 experienced a total of 3.5 (95%UI 3.0 - 3.9) billion life-years post-tuberculosis, with survivors of paediatric tuberculosis contributing 12% (95%UI 7 - 17%) of these life-years. We estimate that 155 (95%UI 138 - 171) million tuberculosis survivors were alive in 2020. The South-East Asia region had the largest proportion of tuberculosis survivors (47%). We estimate that 27 (95%UI 26 - 29) million tuberculosis survivors alive in 2020 were treated within the past 5 years.

Interpretation

The number of tuberculosis survivors alive today is over ten times the estimated annual tuberculosis incidence. Interventions to alleviate respiratory morbidity, screen for and prevent recurrent tuberculosis, and reduce stigma should be immediately prioritised for recently treated tuberculosis survivors.



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# Introduction

An estimated ten million people develop tuberculosis disease annually, with around 70% receiving treatment.[1] While tuberculosis is curable, tuberculosis survivors continue to experience clinical and societal consequences of the disease even after recovery. Despite this, health systems do not generally focus attention on people affected by tuberculosis after treatment completion. The World Health Organization (WHO) reporting requirements for tuberculosis focus on diagnosis and treatment, and WHO epidemiologic estimates and programmatic targets set for countries both fall within these areas. There are limited data available that focus on people who have survived tuberculosis disease or the impact that tuberculosis continues to have on their lives.

There is increasing recognition that tuberculosis exerts an impact on survivors that extends beyond their tuberculosis episode. Those who survive tuberculosis are not only at increased risk of developing tuberculosis again compared to those who have never had tuberculosis,[2] but they have increased all-cause mortality[2,3] and reduced life expectancy[4] irrespective of adequate tuberculosis treatment. Pulmonary tuberculosis is increasingly recognised as an important risk factor for chronic respiratory disease. Persistence of abnormal spirometry (airway obstruction and low forced vital capacity patterns) and chronic or recurrent symptoms beyond cure are well described.[5–7] Even mild and subclinical impairment in forced expiratory volume blown in one second (FEV1) has been shown to be an independent predictor of mortality and cardiovascular disease in addition to respiratory hospitalisation.[8] Reductions in health-related quality of life and exercise tolerance have been noted in individuals following an episode of tuberculosis disease despite successful treatment or cure.[9] Although data are lacking, pulmonary tuberculosis early in life could have significant long-term consequences as prenatal and early childhood are the most critical periods for lung growth and development. Individuals surviving other forms of tuberculosis, particularly tuberculosis meningitis, frequently experience ongoing neurological morbidity,[10] and many tuberculosis survivors have psychological morbidity associated with their disease and treatment.

The social and economic impact of tuberculosis also persists well beyond the end of treatment. Communities may continue to stigmatise or socially isolate tuberculosis survivors, diminishing marriage prospects for young women or prompting divorce.[11,12] Tuberculosis can drive families deeper into poverty both by requiring out-of-pocket expenditure for medical and non-medical costs, as well as by reducing income during tuberculosis treatment.[13] The socioeconomic impact of impoverishment on both the individual and the household may last for many successive years, with children being at high risk of malnutrition or discontinued education.[14]

The first step to addressing the challenges faced by tuberculosis survivors is to determine the number of people affected, their basic demographic characteristics, and where to find them. This information is necessary to help health systems plan interventions directed at mitigating the lasting effects of tuberculosis on survivors. In this study we aimed to model the number of individuals globally who have developed tuberculosis since 1980, the number who have survived to the present day, and the number who have been treated recently and may thus be amenable to public health intervention.

# Methods

Our analysis considered 190 countries, comprising 99% of the global population for 2020 and 98% of estimated 2018 tuberculosis incidence. We sought to characterise those alive in 2020 of those who had survived tuberculosis since 1980, the first year of tuberculosis notification data collated by WHO. An overview of the methodology is presented in Figure 1, and more detailed methods are provided in an online Appendix.

## Numbers surviving anti-tuberculosis treatment episodes

We used country data collated by the WHO on notified tuberculosis between 1980 and 2018. Notifications for India were altered to account for two major changes in reporting: a change in definition in 1991 resulting in a drop, and the wider inclusion of the private sector from 2013. We scaled Indian notifications by a single factor prior to 1991 and a linearly increasing factor for the years 1991 - 2013 (see Appendix). Missing notification counts (including 2019) were imputed using a Kalman smoother. To avoid double counting of recurrent tuberculosis, notifications were scaled to represent only new tuberculosis cases using country-specific averages of the ratio between new and relapse notifications, or regional averages where data were lacking. Country-specific averages of the proportion of cases notified in each sex and age category were used to disaggregate notifications in each year by sex and ages 0-4, 5-14, 15-24, 25-34, 35-44, 45-54, 55-64, and 65+ years, using averages where data were lacking. WHO-collated treatment outcome data were aggregated for each country across years and type of tuberculosis disease, and taken not to vary by age, sex or HIV/ART-status. The fraction of cases surviving treatment was constructed assuming the same proportion of death among those lost-to-follow-up as among those with follow-up.

To disaggregate the numbers surviving anti-tuberculosis treatment (ATT) into single year age groups, we made use of population estimates for each country from the United Nations World Population Prospects 2019 (WPP19), which we linearly interpolated to single year and age groups. We assumed that the tuberculosis notification rates were flat within each age group (0-4, 5-14, 15-24, 25-34, 35-44, 45-54, 55-64, and 65+ years) separately for each sex, and applied these rates to the single-year age group population estimates.

To estimate the proportion of cases living with HIV, we focussed on the set of countries with population over 1 million in 2020 where the Institute of Health Metrics and Evaluation (IHME) estimated HIV prevalence exceeded 1% in at least one age group between 1990 - 2017. For these countries we extrapolated WHO estimates of the proportion of tuberculosis cases with HIV between 2000 and 2017 to the range 1980 - 2019 using a Kalman smoother, together with an assumed proportion of $10^{-10}$ prior to 1980. HIV-associated tuberculosis cases were disaggregated by age and sex proportional to estimated HIV-prevalence in each group and sex.

## Numbers surviving untreated tuberculosis episodes

To account for those who have survived tuberculosis without receiving ATT, we made use of WHO estimates of tuberculosis incidence 2000 - 2018. We took the gap between incidence and new and relapse notifications to represent the number in each country and year with untreated tuberculosis, and used the ratio of new to relapse cases derived from notification data to exclude relapse tuberculosis cases. WHO incidence estimates were extrapolated forwards one year using a Kalman smoother and

prior to 2000 we assumed incidence followed trends in notifications. Countries where tuberculosis notifications in 2000 divided by notifications in some year prior to 2000 exceeded the mean of this quantity across all country years by more than three standard deviations (9 countries) were considered outliers; we assumed their incidence was constant between 1980 and 2000. We again used the extrapolated WHO estimates of HIV prevalence in incident tuberculosis to determine the fraction of cases that were HIV-associated, disaggregating this by age and sex proportional to HIV prevalence in each category. We computed an ART coverage among those living with HIV by extrapolating UNAIDS coverage estimates with a Kalman smoother.

To capture differential tuberculosis detection among children, we used ratios of WHO new and relapse notifications to tuberculosis incidence for 0-4, 5-14 and 15+ year age groups in each country to compute a relative risk of not receiving tuberculosis treatment compared to adults. These relative risks were used to up-weight each age group's fraction of tuberculosis notifications to generate the fraction of incidence in each age group.

Case-fatality ratios for untreated tuberculosis were modelled differently for 0-4, 5-14 and 15+ year age groups, and by HIV/ART status. We used the same case-fatality ratios as the WHO estimation process, which are based on systematic reviews of pre-chemotherapy literature for HIV-negative individuals, and a mixture of literature, programme data and expert opinion for people with HIV (see Appendix).

## Survival after tuberculosis episodes

For the country-, sex- and age-specific baseline mortality rate over time, we used WPP19 estimates, and undertook bilinear interpolation to obtain the force of mortality by age and time at single year resolution.

For those who survived tuberculosis, we assumed the force of mortality was a factor 2.91 (2.21 - 3.84) times higher than in those who had never had tuberculosis, based on Romanowski et al:[3] a systematic review and meta-analysis of relative all-cause mortality after anti-tuberculosis treatment. We applied this hazard ratio independent of country, time, sex, age, HIV-status and also whether anti-tuberculosis treatment was received or not. Sensitivity analyses included using values of 2 and 4, and considering a linear decline to no effect between 5 and 10 years after tuberculosis.

For the countries where we explicitly modelled HIV (see above), we estimated HIV-specific mortality by country, sex, age and time. To do this, we first extrapolated IHME prevalence estimates by country, age, and sex to include the years 1975 - 2020. We fitted cubic splines to the log prevalences between 1990 - 2018 appending a point in 1975 with prevalence of $10^{-10}$, and predicted prevalence in other years. We then estimated a force of mortality in HIV-negative individuals by identifying the 'bumps' over calendar time for each country, sex and age group due to HIV as the period from when the force of mortality first increased up to 2050, and interpolating the force of mortality with the bump removed using a log-linear trend. We neglected HIV in those aged over 80 years. The excess mortality in a given country, year, sex and age group was assumed due to HIV, based on the extrapolated IHME HIV prevalence estimates. For these countries, this procedure yielded separate country-, time-, sex- and age-specific forces of mortality for people living with HIV and those without HIV infection.

## Metrics calculated

This approach allowed us to calculate for each country the number of new tuberculosis cases occurring 1980 - 2019, the numbers who received ATT or went untreated, and for each treatment group, the life-years lived after tuberculosis up to 2020 and the number of people still alive in 2020. We also calculated the number who had survived tuberculosis after treatment in the last 5 or 2 years, and stratified results by age and sex. Results were aggregated to a global or WHO region level. Uncertainty in outputs was computed by propagating variances associated with inputs through calculations analytically. Uncertainty for aggregate quantities in a country was assumed to be perfectly correlated over time, but uncorrelated with other countries. All code and input data required to reproduce this analysis are publicly available (see Appendix).

## Role of the funding source

The funding source had no role in the design of this study and did not have any role during its execution, analyses, interpretation of the data, or in the decision to submit results.

# Results

We estimate that between 1980-2019, a total of 363 million (95% uncertainty interval [UI] 287 - 438 million) people globally developed new tuberculosis disease, of whom 172 million (95%UI 169 - 174 million) initiated treatment (Table 1). Individuals who developed tuberculosis between 1980-2019 lived 3 480 million (95%UI 3 040 - 3 920 million) life-years post-tuberculosis by 2020 (Figure 2). Those who developed tuberculosis when they were <15 years old contributed 12% (95%UI 7 - 17%) of the post-tuberculosis life-years lived in this period.

We estimate that 155 million (95%UI 138 - 171 million) people who had had new tuberculosis disease and survived that disease episode were still alive in 2020. Of these, 96 million (95%UI 89 - 104 million) had initiated treatment and 58 million (95%UI 43 - 73 million) were never treated. The WHO South East Asia region had the largest population of tuberculosis survivors alive in 2020, reflecting the burden of tuberculosis cases: 47% (95%UI 37 - 57%) of the total. Among tuberculosis survivors alive in 2020, 59% (95%UI 49 - 69%) were male, and the median and interquartile range (IQR) for current age of tuberculosis survivors alive in 2020 were 45 (33 - 57) years (Figure 3). Furthermore, 8% (95%UI 6 - 10%) were people who had HIV at the time that they developed new tuberculosis. On average, tuberculosis survivors alive in 2020 had lived a median (IQR) 12 (6 - 21) years after their first tuberculosis episode.

Among tuberculosis survivors alive in 2020, 18% (95%UI 16 - 20%) were treated in the past 5 years, including 8% (95%UI 7 - 9%) treated in the past 2 years (Table 2). Among this relatively accessible group of those treated in the past 5 years, 62% (95%UI 57 - 66%) were male, and the median (IQR) for current age was 38 (26 - 52) years. In the WHO Eastern Mediterranean region, over 10% of recently treated tuberculosis survivors alive in 2020 were children <15 years old, a figure largely driven by Pakistan, which accounts for around 70% of case notifications in the region (see Appendix). In the WHO Africa region, 44% (95%UI 18 - 69%) of the tuberculosis survivors alive in 2020 and treated in the past 5 years were people who had HIV at the time that they developed tuberculosis, suggesting that they could be reached through HIV programs.

Varying mortality hazard ratios between 2 and 4 changed central estimates of survivors by approximately 10%; assuming a declining hazard ratio increased estimates by up to 20% (see Appendix). Intermediate and supplementary results are available in the Appendix.

# Discussion

This study provides the first comprehensive estimate of the global number of tuberculosis survivors; we estimate that 155 million individuals are alive today who developed tuberculosis between 1980-2019. This is a conservative estimate of all tuberculosis survivors as some individuals alive today will have developed tuberculosis prior to 1980. Approximately 27 million tuberculosis survivors who were treated within the past five years are a relatively accessible group that could be identified, evaluated for post tuberculosis morbidity, provided with appropriate clinical care, and supported financially and psychologically. Since 2017, the WHO has published estimates of lives saved by tuberculosis programs, most recently stating that 58 million lives were saved between 2000-2018.[1] Our study presents a complementary estimate, which quantifies the total population of tuberculosis survivors alive today. Knowing the number of tuberculosis survivors is also a first step toward applying a disability-adjusted life-year framework to fully quantify the burden of tuberculosis, as has recently been advocated.[15] Given that the total population of tuberculosis survivors is over ten times greater than the number estimated to develop tuberculosis disease every year, even a modest level of post-recovery disability has major implications for tuberculosis morbidity estimates.

Within the large population of tuberculosis survivors that we estimate to be alive today, many individuals have complex health needs that are not being addressed by current health systems. A prior episode of tuberculosis increases the risk of recurrent tuberculosis disease compared to the tuberculosis naïve population,[2,16] with higher risks of unfavourable treatment outcomes.[17] Chronic respiratory symptoms experienced by many post-tuberculosis patients may complicate the diagnosis of recurrent tuberculosis versus other respiratory conditions.[18] To ensure that tuberculosis survivors receive appropriate clinical care, active clinical surveillance of tuberculosis survivors should adopt a multidisciplinary approach that involves not only tuberculosis programs but non-communicable disease clinics, such as those that manage chronic respiratory diseases. Where available, lung function evaluation could be undertaken to identify a variety of lung function impairments, with appropriate initiation of, for example, inhaled bronchodilator, prophylactic antibiotics or steroid therapy. Even in settings with limited health system capacity for managing chronic respiratory conditions, interventions such as pneumococcal vaccination, pulmonary rehabilitation, and promotion of smoking cessation could help mitigate the impact of ongoing respiratory morbidity and improve quality of life for tuberculosis survivors.

We estimate that 12% of the post-tuberculosis life years experienced globally were due to tuberculosis during childhood. Although limited data are available on the long-term consequences of tuberculosis in children, there is clear evidence that impaired early lung function persists throughout life.[19–21] Therefore, it is likely that a chronic lung infection like tuberculosis experienced in childhood will exert a lifelong impact on lung function. Other lower respiratory tract infections during infancy have been shown to reduce lung function in childhood.[22,23] Moreover, studies have found prior history of pulmonary tuberculosis or severe lower respiratory tract infection to be independently associated with worse lung function in adolescents.[24,25] It therefore follows that protecting lung growth and capacity early in life is critically important for outcomes later in life. In the context of tuberculosis this means improving prevention and early diagnosis in childhood.

In addition to the health consequences, it is important to consider the financial impact on individuals with tuberculosis disease, especially given that many are already living in poverty. These costs can be catastrophic and long-lasting, impacting both patients and their family members.[11–14] Social protection programs providing money, food, or services like housing could mitigate these long-term

consequences in addition to reducing the direct and indirect costs of treatment in the short term. An example of this is Brazil's Bolsa Familia program which has been shown to improve tuberculosis treatment outcomes, in large part by reducing barriers to continuity of care.[26,27] It is important to explore whether these programs can help patients avoid catastrophic costs and future socio-economic repercussions after treatment.[28]

Given the large number of tuberculosis survivors alive today, our results highlight several areas of research importance for understanding the long-term impact that tuberculosis exerts on these survivors. Post-tuberculosis structural lung pathology and respiratory morbidity remain poorly defined and understood.[29] There is a critical need for large prospective cohort studies, including both children and adults, to determine the evolution of post-tuberculosis lung damage and its associated morbidity, including exercise capacity and health-related quality of life assessments. More mechanistic studies are required to understand the pathophysiology of post-tuberculosis lung impairment, which could better define and inform therapies to prevent or treat this condition. Current clinical trials of new tuberculosis treatments are largely focused on recurrence-free survival outcomes with limited consideration for lung health and quality of life post tuberculosis. The large burden of tuberculosis survivors highlights the need for trials to additionally assess the impact of therapy on post-treatment morbidity and not only microbiological cure. Finally, more research is required to better understand which interventions might be most effective in alleviating the financial and stigmatizing effects of having had tuberculosis.

Our study has several important limitations. Notification data reported to WHO were not available for 2019 and WHO only estimated incidence from 2000 onwards. These and other missing data required imputation. We employed the widely-used WHO estimates of tuberculosis incidence, which include the HIV-associated fraction; these estimates have their own limitations. Our assumption that non-notified tuberculosis was not treated may underestimate survivors in countries with large private sectors or incomplete reporting systems. Our approach to HIV and ART was also limited by the available data; we used IHME estimates to inform age- and sex-specific prevalence, but had to extrapolate estimates to earlier years. We also did not specifically differentiate drug-resistant tuberculosis. We may underestimate survivor numbers by not accurately accounting for recurrent tuberculosis in previously untreated individuals who receive treatment for their second episode. However, we estimate this effect is limited to a few percent.

A key parameter is the mortality hazard ratio for survival post the tuberculosis episode, which we took from Romanowski et al.[3] This pooled estimate is subject to large heterogeneity, and is specific to survivors of tuberculosis treatment. We applied it to both treated and untreated survivors and did not consider heterogeneity by age or setting. However, our sensitivity analyses around this parameter show our estimates are robust to reasonable variation, particularly for those recently treated. Overall uncertainty in our estimates of treated survivors is largely driven by this hazard ratio. Estimates of untreated survivors are more uncertain since they additionally rely on uncertain incidence estimates and uncertain case-fatality ratios for the tuberculosis episode. Finally, limitations in estimates of input uncertainty, and particularly their correlations, mean our uncertainty results are less robust than our central estimates.

Over 150 million individuals are alive today who have survived tuberculosis, many of whom experience substantial health, financial and social consequences that are currently poorly understood and therefore not addressed by health and social care systems. Some existing interventions could be used to prevent recurrent tuberculosis (such as tuberculosis preventive therapy) and reduce future

mortality. In addition, interventions are also available that may alleviate some of the patterns of respiratory morbidity. These interventions, as well as active screening for recurrent tuberculosis, should be immediately prioritized for recently treated tuberculosis survivors, who should be relatively identifiable by health systems. In addition, far more research is required to better understand the tuberculosis survivor population and develop new interventions to prevent or treat post tuberculosis morbidity. Finally, monitoring of tuberculosis survivors should be incorporated into recording and reporting systems, as India has done by requiring six-monthly follow-up evaluations of tuberculosis survivors for 2 years after treatment. While it will take time for health systems to build capacity to implement long-term monitoring, adopting long-term indicators is an important step toward ensuring that the health of tuberculosis survivors is considered an integral part of the tuberculosis care cascade, and that the journey does not end with treatment completion.

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## Conflicts of Interest

None declared.

## Author Contribution

Conceptualization: PJD, JAS.
Data curation, methodology, formal analysis, visualisation and software: PJD.
Review of methods and interpretation of results: all authors.
Initial draft and writing and editing article: all authors.
Approval of final draft: all authors.
The corresponding author had full access to all data and final responsibility to submit the article for publication.

**Table 1: Global and regional new tuberculosis cases, new cases treated, life-years lived 1980-2020, and tuberculosis survivors in 2020**

| | Africa | The Americas | Eastern Mediterranean | Europe | South-East Asia | Western Pacific | Global |
|---|---|---|---|---|---|---|---|
| Total new tuberculosis cases 1980-2019 | 72 400 000 ( 60 800 000 - 84 000 000) | 11 500 000 ( 10 700 000 - 12 400 000) | 25 600 000 ( 2 230 000 - 48 900 000) | 14 300 000 ( 12 200 000 - 16 300 000) | 161 000 000 ( 95 100 000 - 227 000 000) | 77 800 000 ( 51 800 000 - 104 000 000) | 363 000 000 ( 287 000 000 - 438 000 000) |
| New tuberculosis cases treated 1980-2019 | 32 300 000 ( 31 900 000 - 32 700 000) | 9 120 000 ( 9 000 000 - 9 230 000) | 12 500 000 ( 12 400 000 - 12 600 000) | 12 000 000 ( 11 800 000 - 12 100 000) | 68 500 000 ( 66 500 000 - 70 500 000) | 37 300 000 ( 36 400 000 - 38 200 000) | 172 000 000 ( 169 000 000 - 174 000 000) |
| New tuberculosis cases not treated 1980-2019 | 39 800 000 ( 36 100 000 - 43 500 000) | 2 320 000 ( 2 200 000 - 2 440 000) | 13 300 000 ( 8 810 000 - 17 900 000) | 2 350 000 ( 2 050 000 - 2 640 000) | 92 000 000 ( 70 800 000 - 113 000 000) | 39 900 000 ( 29 800 000 - 49 900 000) | 190 000 000 ( 166 000 000 - 214 000 000) |
| Post-tuberculosis life-years 1980-2020 | 499 000 000 ( 378 000 000 - 620 000 000) | 147 000 000 ( 143 000 000 - 151 000 000) | 286 000 000 ( 199 000 000 - 374 000 000) | 181 000 000 ( 175 000 000 - 188 000 000) | 1 590 000 000 (1 230 000 000 - 1 960 000 000) | 771 000 000 ( 588 000 000 - 955 000 000) | 3 480 000 000 (3 040 000 000 - 3 920 000 000) |
| Post-tuberculosis life-years among treated individuals 1980-2020 | 267 000 000 ( 164 000 000 - 370 000 000) | 127 000 000 ( 123 000 000 - 130 000 000) | 166 000 000 ( 160 000 000 - 171 000 000) | 160 000 000 ( 157 000 000 - 163 000 000) | 794 000 000 ( 757 000 000 - 832 000 000) | 421 000 000 ( 408 000 000 - 434 000 000) | 1 940 000 000 (1 820 000 000 - 2 050 000 000) |
| Post-tuberculosis life-years among untreated individuals 1980-2020 | 232 000 000 ( 168 000 000 - 295 000 000) | 20 200 000 ( 18 000 000 - 22 400 000) | 121 000 000 ( 33 400 000 - 208 000 000) | 21 200 000 ( 15 400 000 - 26 900 000) | 801 000 000 ( 434 000 000 - 1 170 000 000) | 350 000 000 ( 167 000 000 - 533 000 000) | 1 540 000 000 (1 120 000 000 - 1 970 000 000) |
| Total tuberculosis survivors alive in 2020 | 25 700 000 ( 18 600 000 - 32 800 000) | 5 510 000 ( 5 320 000 - 5 700 000) | 12 600 000 ( 9 430 000 - 15 800 000) | 6 710 000 ( 6 460 000 - 6 960 000) | 72 200 000 ( 58 700 000 - 85 700 000) | 31 900 000 ( 26 600 000 - 37 200 000) | 155 000 000 ( 138 000 000 - 171 000 000) |
| Treated tuberculosis survivors alive in 2020 | 15 200 000 ( 8 460 000 - 21 900 000) | 4 780 000 ( 4 610 000 - 4 950 000) | 7 750 000 ( 7 470 000 - 8 030 000) | 6 020 000 ( 5 820 000 - 6 220 000) | 41 700 000 ( 39 500 000 - 43 900 000) | 21 000 000 ( 20 200 000 - 21 900 000) | 96 400 000 ( 89 300 000 - 104 000 000) |
| Untreated tuberculosis survivors alive in 2020 | 10 500 000 ( 8 200 000 - 12 800 000) | 734 000 ( 653 000 - 815 000) | 4 870 000 ( 1 690 000 - 8 060 000) | 693 000 ( 540 000 - 846 000) | 30 500 000 ( 17 200 000 - 43 900 000) | 10 800 000 ( 5 580 000 - 16 100 000) | 58 200 000 ( 43 300 000 - 73 000 000) |

**Table 2: Global and regional tuberculosis survivors in 2020 treated within 5 and 2 years**

| Region | Total | % male | % under 15 years old | Total | % male | % under 15 years old |
|---|---|---|---|---|---|---|
| | Treated within 5 years | | | Treated within 2 years | | |
| Africa | 4 992 000 ( 3 402 000 - 6 581 000) | 58 | 7.6 | 2 166 000 ( 1 556 000 - 2 776 000) | 59 | 8.1 |
| The Americas | 957 600 ( 944 200 - 971 100) | 62 | 4.5 | 407 500 ( 402 300 - 412 800) | 63 | 4.8 |
| Eastern Mediterranean | 2 270 000 ( 2 236 000 - 2 304 000) | 51 | 10.6 | 968 700 ( 958 400 - 979 100) | 51 | 11.7 |
| Europe | 977 500 ( 942 100 - 1 013 000) | 65 | 3.5 | 376 700 ( 359 600 - 393 700) | 65 | 3.9 |
| South-East Asia | 12 420 000 (12 240 000 - 12 610 000) | 62 | 6.0 | 5 764 000 ( 5 706 000 - 5 822 000) | 62 | 6.6 |
| Western Pacific | 5 794 000 ( 5 693 000 - 5 895 000) | 66 | 3.7 | 2 505 000 ( 2 474 000 - 2 536 000) | 67 | 4.1 |
| Global | 27 410 000 (25 810 000 - 29 020 000) | 61 | 6.0 | 12 190 000 (11 570 000 - 12 800 000) | 62 | 6.6 |

# Figure captions

**Figure 1**: **Summary of estimation process**

**Figure 2: Life-years lived post-tuberculosis 1980-2020 by age at first tuberculosis, sex, region and tuberculosis treatment status**

**Figure 3: Number of tuberculosis alive 2020 by current age, sex, region and tuberculosis treatment status**

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Figure 1

# Notes

Everthing is stratified by country

Everything is stratified by time

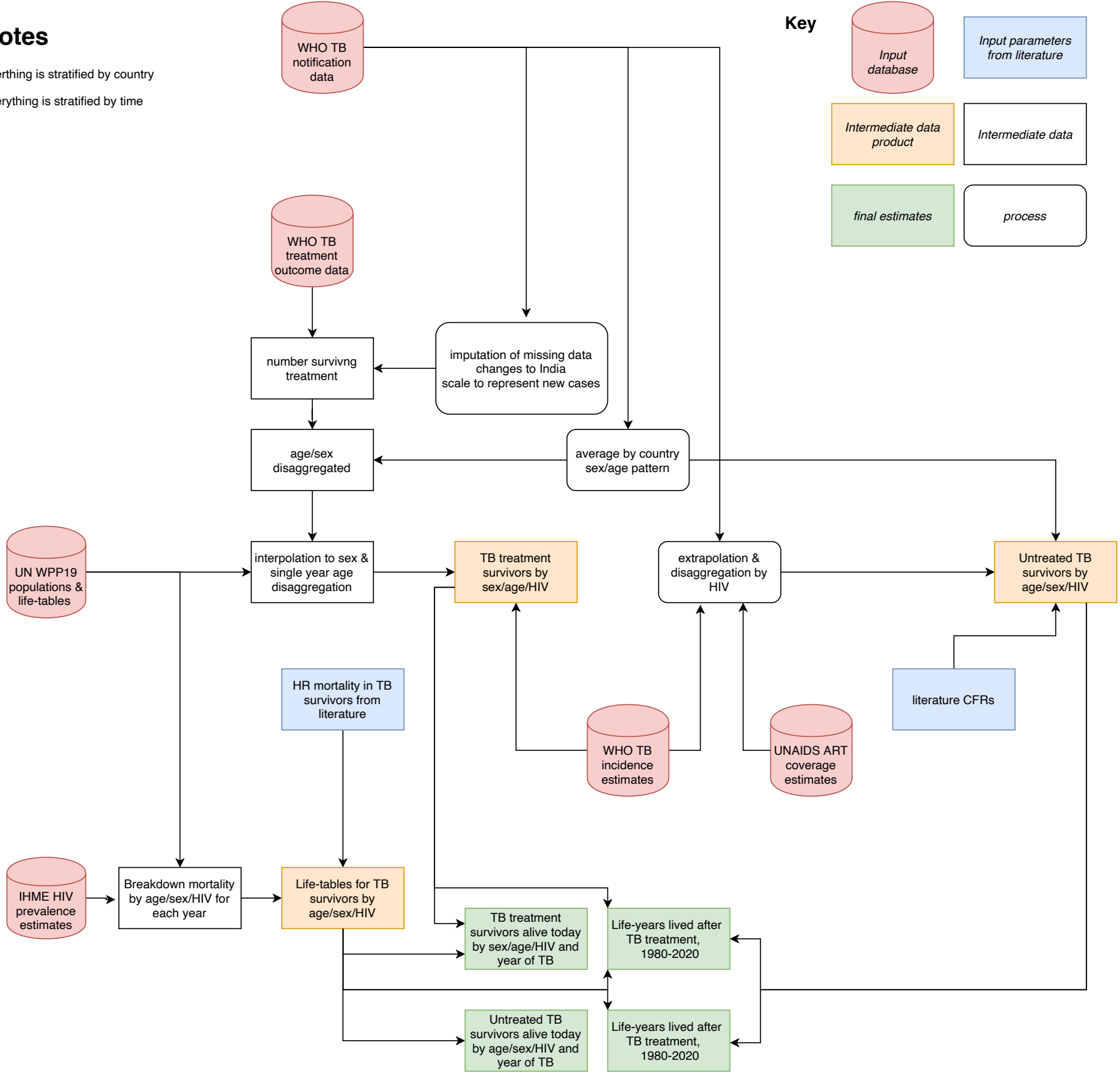
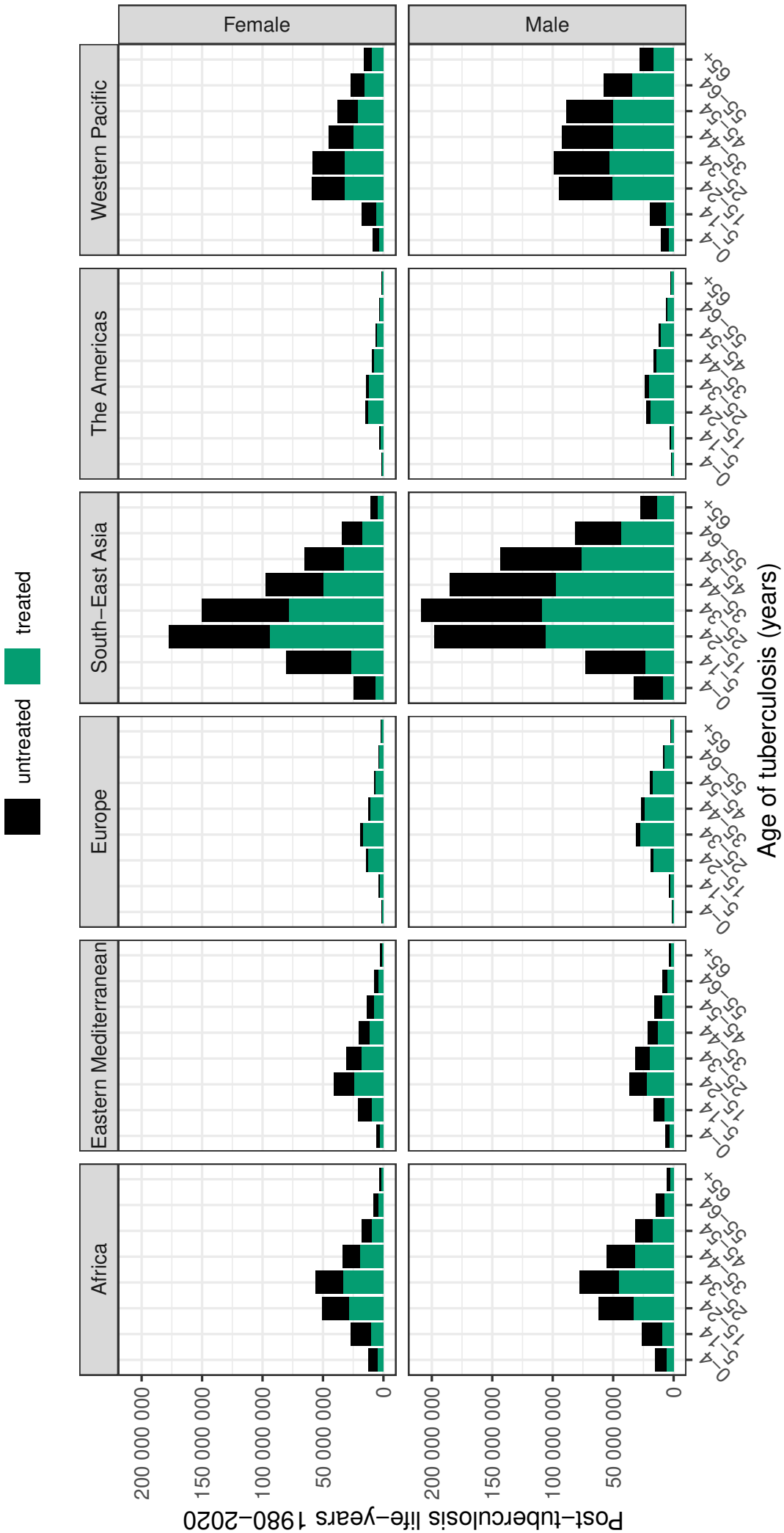
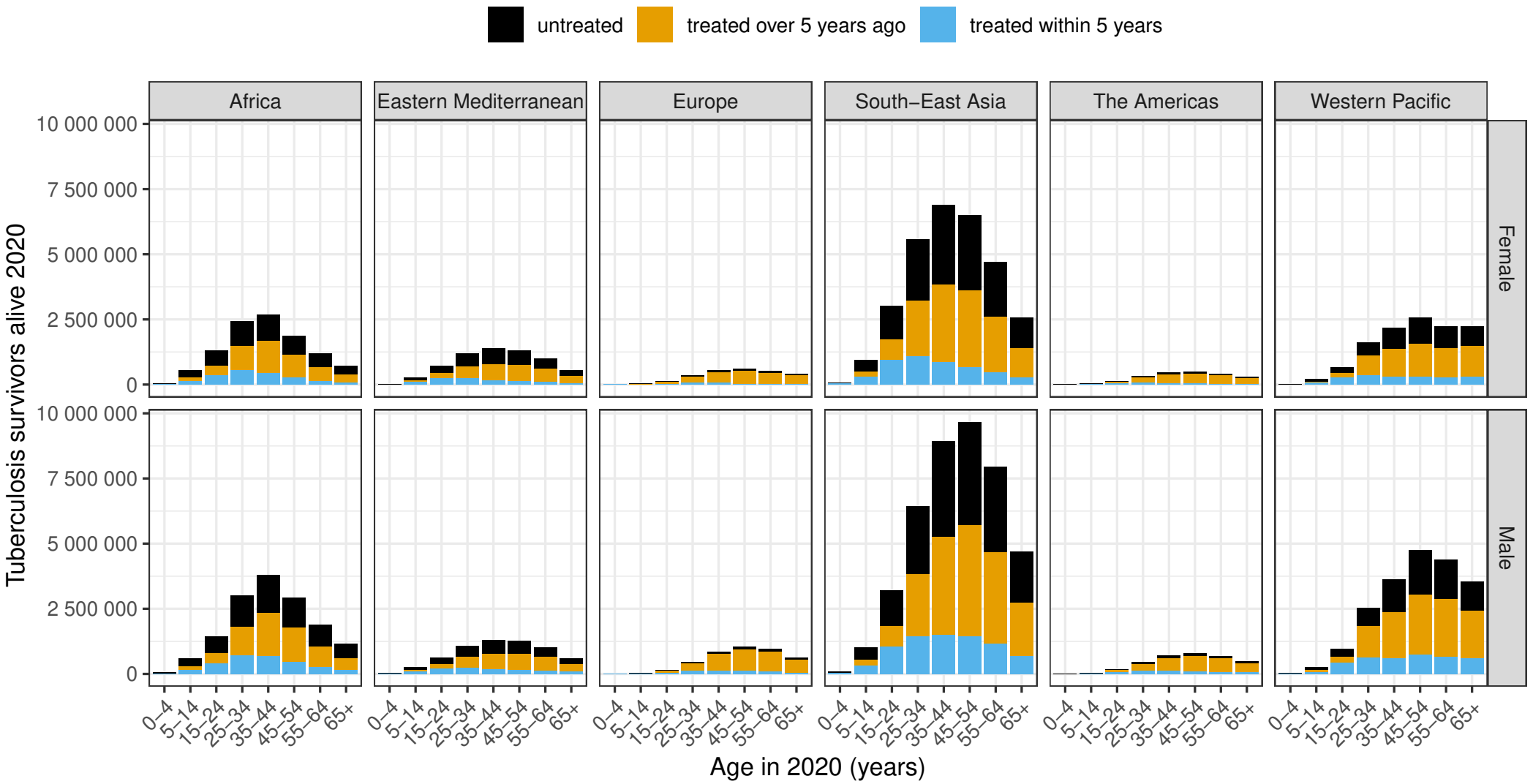


Figure 2


Female
Male
Western Pacific
The Americas
South-East Asia
Europe
Eastern Mediterranean
Africa
0
50 000 000
100 000 000
150 000 000
200 000 000
Post-tuberculosis life-years 1980–2020
0–4
5–14
15–24
25–34
35–44
45–54
55–64
65+
Age of tuberculosis (years)
untreated
treated


untreated
treated over 5 years ago
treated within 5 years
Africa
Eastern Mediterranean
Europe
South−East Asia
The Americas
Western Pacific
Female
Male
Tuberculosis survivors alive 2020
10 000 000
7 500 000
5 000 000
2 500 000
0
0–4
5–14
15–24
25–34
35–44
45–54
55–64
65+
Age in 2020 (years)