Tuberculosis (TB) remains a major global health problem, responsible for ill health among millions of people each year. TB ranks as the second leading cause of death from an infectious disease worldwide, after the human immunodeficiency virus (HIV). The latest estimates included in this report are that there were 9.0 million new TB cases in 2013 and 1.5 million TB deaths (1.1 million among HIV-negative people and 0.4 million among HIV-positive people). These totals are higher than those included in the 2013 global TB report, primarily because of upward revisions to estimates of the number of TB cases and deaths in Nigeria following the finalization of results from the country’s first-ever national TB prevalence survey (completed in 2012). Given the size of the population and the high TB burden in Nigeria, these revisions have affected global estimates.

Though most TB cases and deaths occur among men, the burden of disease among women is also high. In 2013, there were an estimated 3.3 million cases and 510 000 TB deaths among women, as well as an estimated 550 000 cases and 80 000 deaths among children.1 TB mortality is unacceptably high given that most deaths are preventable if people can access health care for a diagnosis and the correct treatment is provided. Short-course regimens of first-line drugs that can cure around 90% of cases have been available for decades. Basic facts about TB are summarized in Box 1.1.

These large numbers of TB cases and deaths notwithstanding, 21 years on from the 1993 World Health Organization (WHO) declaration of TB as a global public health emergency, major progress has been made. Globally, the TB mortality rate (deaths per 100 000 population per year) has fallen by 45% since 1990 and TB incidence rates (new cases per 100 000 population per year) are decreasing in most parts of the world. Between 2000 and 2013, an estimated 37 million lives were saved through effective diagnosis and treatment.

The global TB strategy developed by WHO for the period 2006–2015 is the Stop TB Strategy (Box 1.2).2

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**BOX 1.1**

**Basic facts about TB**

TB is an infectious disease caused by the bacillus *Mycobacterium tuberculosis*. It typically affects the lungs (pulmonary TB) but can affect other sites as well (extrapulmonary TB). The disease is spread in the air when people who are sick with pulmonary TB expel bacteria, for example by coughing. Overall, a relatively small proportion of people infected with *M. tuberculosis* will develop TB disease. However, the probability of developing TB is much higher among people infected with HIV. TB is also more common among men than women, and affects mainly adults in the most economically productive age groups.

The most common method for diagnosing TB worldwide is sputum smear microscopy (developed more than 100 years ago), in which bacteria are observed in sputum samples examined under a microscope. Following recent breakthroughs in TB diagnostics, the use of rapid molecular tests to diagnose TB and drug-resistant TB is increasing. In countries with more developed laboratory capacity, cases of TB are also diagnosed via culture methods (the current reference standard).

Without treatment, TB mortality rates are high. In studies of the natural history of the disease among sputum smear-positive/HIV-negative cases of pulmonary TB, around 70% died within 10 years; among culture-positive (but smear-negative) cases, 20% died within 10 years.\(^a\)

Effective drug treatments were first developed in the 1940s. The most effective first-line anti-TB drug, rifampicin, became available in the 1960s. The currently recommended treatment for new cases of drug-susceptible TB is a six-month regimen of four first-line drugs: isoniazid, rifampicin, ethambutol and pyrazinamide. Treatment success rates of 85% or more for new cases are regularly reported to WHO by its Member States. Treatment for multidrug-resistant TB (MDR-TB), defined as resistance to isoniazid and rifampicin (the two most powerful anti-TB drugs) is longer, and requires more expensive and more toxic drugs. For most patients with MDR-TB, the current regimens recommended by WHO last 20 months, and treatment success rates are much lower.

For the first time in four decades, new TB drugs are starting to emerge from the pipeline, and combination regimens that include new compounds are being tested in clinical trials. There are several TB vaccines in Phase I or Phase II trials. For the time being, however, a vaccine that is effective in preventing TB in adults remains elusive.

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1 The estimated number of deaths among children excludes TB deaths in HIV-positive children, for which estimates are not yet available. Further details are provided in Chapter 2.

The overarching goal of this strategy is to achieve 2015 global targets for reductions in the burden of disease caused by TB. These targets are that incidence should be falling, and that prevalence and incidence rates should be halved by 2015 compared with 1990 levels.

The end of 2015 is significant, representing a transition between the Millennium Development Goals (MDGs) established in 2000 and a post-2015 development framework. By July 2014, following the work of a high-level panel and ongoing consultations, a set of 17 Sustainable Development Goals (SDGs) with targets set for 2030 had been proposed.1 The third of these goals, “Ensure healthy lives and promote well-being for all at all ages”, includes a target to “end the epidemics of AIDS, tuberculosis, malaria, and neglected tropical diseases and combat hepatitis, water-borne diseases, and other communicable diseases”
by 2030. It is anticipated that the SDGs will be finalized by September 2015.

Within this broader context and contributing to the development of health-related SDGs, in 2012 WHO initiated the development of a post-2015 global TB strategy. Following an extensive consultation process, the strategy was endorsed by all Member States at the 2014 World Health Assembly in resolution WHA 67.1. The overarching goal of the post-2015 strategy is to end the global TB epidemic by 2035, with corresponding global targets for a 95% reduction in TB deaths compared with 2015; a 90% reduction in TB incidence rate; and no affected families facing catastrophic costs due to TB.

In the context of global TB strategies and targets, WHO has published a global TB report every year since 1997 (Figure 1.1). The main aim of the report is to provide a comprehensive and up-to-date assessment of the TB epidemic and progress in prevention, diagnosis and treatment of the disease at global, regional and country levels, based primarily on data that are reported by countries and territories to WHO in annual rounds of global TB data collection (Box 1.4). This 2014 global TB report is the nineteenth in the series of annual reports, and uses data reported by a total of 202 countries and territories including 183 Member States that account for over 99% of the world’s estimated cases of TB (Table 1.1).

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1 http://www.who.int/tb/post2015_TBstrategy.pdf?ua=1
**BOX 1.4**

**Data collected in WHO 2014 round of global TB data collection**

Data were requested on the following topics: TB case notifications and treatment outcomes, including breakdowns by TB case type, age, sex and HIV status; an overview of services for the diagnosis and treatment of TB; laboratory diagnostic services; drug management; monitoring and evaluation; surveillance and surveys of drug-resistant TB; management of drug-resistant TB; collaborative TB/HIV activities; TB infection control; engagement of all care providers in TB control; the budgets of national TB control programmes (NTPs) in 2014; utilization of general health services (hospitalization and outpatient visits) during treatment; and NTP expenditures in 2013. A shortened version of the online questionnaire was used for high-income countries (that is, countries with a gross national income per capita of ≥US$ 12 746 in 2013, as defined by the World Bank\(^a\) and/or low-incidence countries (defined as countries with an incidence rate of <20 cases per 100 000 population or <10 cases in total).

Countries reported data using an online web-based system (https://extranet.who.int/tme). The system was opened for reporting on 19 March, with a deadline of 14 May for all WHO regions except for the Region of the Americas and the European Region (these had a deadline of 30 May). Countries in the European Union submitted notification data to a system managed by the European Centre for Disease Prevention and Control (ECDC). Data from the ECDC system were uploaded into the WHO online system.

Data were reviewed, and, where appropriate, followed up with countries by a team of reviewers. Validation of data by respondents was also encouraged via a series of real-time checks of submitted data. Following corrections and updates by countries, the data used for the main part of this report for most countries were those available on 29 July 2014; for a few countries that corrected their data when country profiles were sent for review, the data available on 11 August were used. The detailed data tables for key indicators provided alongside the report were produced using data available on 6 October, and include additional data from a few European countries.\(^b\)

In addition to the data reported through the online global TB data collection system, data about TB screening and the provision of isoniazid preventive therapy (IPT) to people living with HIV and antiretroviral therapy (ART) for HIV-positive TB patients were collected by the HIV department in WHO and the Joint United Nations Programme on HIV/AIDS (UNAIDS). The data were jointly validated by the WHO’s Global TB Programme and HIV department, and UNAIDS.

\(^a\) For this reason, there may be slight discrepancies between the main part of the report and the data on the accompanying CD-rom and online global TB database.

**FIGURE 1.1**

Eighteen annual WHO global TB reports, 1997–2013

<table>
<thead>
<tr>
<th>1997: First report: epidemiology and surveillance</th>
<th>2002: Added financing and strategy for 22 high-burden countries (HBCs)</th>
<th>2003: Financing and strategy (all countries)</th>
</tr>
</thead>
</table>

July 2009: Online data collection introduced

December 2009: Short update to 2009 report in transition to earlier reporting of data and report publication
The main part of the report contains eight major chapters. Each chapter is intended to stand alone, but links to other chapters are highlighted where appropriate.

**Chapter 2** contains the latest estimates of the burden of disease caused by TB and assessment of progress towards the 2015 targets at global, regional and country levels. Estimates for women and children specifically, and the results and lessons learned from the recent national TB prevalence survey in Nigeria, are given particular attention. The latest status of efforts to improve the measurement of TB cases and deaths at country level, with guidance and support from the WHO Global Task Force on TB Impact Measurement, is described.

With the end of 2015 just one year away, **Chapter 3** provides a snapshot of the status of progress towards 2015 global targets in the 22 high-burden countries (HBCs) that account for 80% of the world’s TB cases, in WHO’s six regions, and globally. This covers progress towards the overarching targets for reductions in disease burden (incidence, prevalence, mortality). It also summarizes progress towards related 2015 targets for TB detection and treatment that have been set for two additional indicators included in the MDG framework (the case detection rate and the treatment success rate for new TB cases) and targets set for the response to the epidemics of TB/HIV and multidrug-resistant TB (MDR-TB) as part of the latest Global Plan to Stop TB.

**Chapter 4** presents data on the numbers of cases notified to NTPs and reported to WHO, and their treatment outcomes, including breakdowns of TB cases by type, sex and age. The chapter highlights recent progress in the contribution of community health workers and volunteers to the referral of TB cases and treatment support, and the role of public-private mix interventions in the post-2015 global TB strategy.

**Chapter 5** focuses on drug-resistant TB. The first part of the chapter covers progress in drug resistance surveillance and associated estimates of the absolute number and proportion of TB patients that have MDR-TB and extensively drug-resistant TB (XDR-TB). The second part of the chapter presents and discusses the latest data on the programmatic response to MDR-TB, including the coverage of testing for drug resistance among new and previously treated TB patients; the number of cases detected with MDR-TB and enrolled on treatment; and treatment outcomes.

**Chapter 6**, on TB diagnostics and laboratory strengthening, covers two main topics. These are the status of laboratory capacity and incorporation of WHO guidance into national policy in 2013, and recent progress in strengthening laboratories and associated diagnostic capacity. It includes the latest data on the roll-out of the rapid molecular test Xpert MTB/RIF since it was recommended in 2010, a multinational project to strengthen laboratory capacity worldwide (EXPAND-TB).

**Chapter 7** contains the most recent data on progress in implementing collaborative TB/HIV activities to jointly address the epidemics of TB and HIV. These include HIV testing for TB patients, provision of antiretroviral therapy (ART) to HIV-positive TB patients, TB screening and isoniazid preventive therapy (IPT) for people living with HIV.

**Chapter 8** assesses financing for TB prevention, diagnosis and treatment. It starts by summarizing estimates of the funding required for a full response to the global TB epidemic up to 2015, which were produced in early 2013 as

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1. The case detection rate, or CDR, is calculated as the number of new cases reported to NTPs in a given year divided by estimated incidence for the same year. The CDR is thus a ratio rather than a rate, but in the context of this indicator the term ‘rate’ has become standard terminology.

part of preparatory work undertaken to inform the replenishment of the Global Fund. The chapter then assesses trends in funding and funding gaps since 2006 based on data reported by NTPs to WHO, including breakdowns by category of expenditure and sources of funding both overall and for country groups defined according to income level, geography and TB burden. Estimates of the cost per patient treated for drug-susceptible and MDR-TB and a new analysis of donor funded using the Organization for Economic Cooperation and Development’s creditor reporting system are also featured.

Chapter 9 discusses research and development for new TB diagnostics, drugs and vaccines. The development pipelines in August 2014 are described and discussed.

The report has three annexes. Annex 1 explains how to use the online WHO global TB database, which is the best source of the latest data reported to and estimates produced by WHO (data for key indicators as of 6 October are also available on the CD-ROM provided with the report). Annex 2 contains country profiles for the 22 HBCs (profiles for other countries are available online1) and Annex 3 contains regional profiles.

The methods used to produce the estimates of disease burden shown in Chapter 2 are available in an online technical appendix (www.who.int/tb/data).

The report is also accompanied by a special supplement. Marking the twenty years since the establishment of the Global Project on Surveillance of anti-TB Drug Resistance, the supplement provides the latest status of progress in surveillance of drug-resistant TB and a new analysis of trends in the burden of drug-resistant TB worldwide. One year on from the 2013 global report’s description of MDR-TB as a “public health crisis”, the supplement also highlights the latest status of the response to the MDR-TB epidemic.

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1 www.who.int/tb/data.
The burden of disease caused by TB

KEY FACTS AND MESSAGES

WHO updates estimates of the burden of disease caused by TB annually, using the latest available data and analytical methods that are explained in a technical appendix and periodically reviewed by an expert group. Estimates are extended to include the most recent calendar year and updates affect the entire time-series back to 1990. For this reason, estimates presented in this chapter for 1990–2012 supersede those of previous reports and direct comparisons (for example, 2012 estimates in this report and 2012 estimates in the last report) are not appropriate.

The data available to estimate TB disease burden continue to improve. In 2013, data from vital registration (VR) systems were used to estimate TB mortality in 126 countries (up from 3 countries in 2008). There has been substantial progress in the implementation of national TB prevalence surveys since 2008, with 16 surveys completed from 2009–2014 and a further 12 underway or planned for 2014–2016.

Final results from national TB prevalence surveys completed from 2011–2013 in Gambia, Lao PDR, Nigeria, Pakistan and Rwanda became available at the end of 2013. Results have provided a recent and direct measure of TB burden at population level in these countries, in four instances for the first time, and used to update estimates of TB prevalence as well as TB incidence and mortality. Upward revisions to estimates of the absolute number of TB cases and deaths in Nigeria have affected global estimates of the absolute number of TB cases and deaths, given the size of the country’s population and TB burden.

In 2013, there were an estimated 9.0 million incident cases of TB and 1.5 million people died from the disease (1.1 million deaths among people who were HIV-negative and 360,000 among people who were HIV-positive). Among these deaths there were an estimated 210,000 from MDR-TB, a relatively high total compared with 480,000 incident cases of MDR-TB. An estimated 13% of new TB cases were HIV-positive in 2013.

The South-East Asia and Western Pacific Regions collectively accounted for 56% of the world’s TB cases in 2013. The African Region had approximately one quarter of the world’s cases, and the highest rates of cases and deaths relative to population (280 incident cases per 100,000 on average, more than double the global average of 126). India and China had the largest number of cases (24% and 11% of the global total, respectively).

The MDG target of halting and reversing TB incidence by 2015 has already been achieved globally. The TB incidence rate fell at an average rate of 1.5% per year between 2000 and 2013. Globally by 2013, the TB mortality rate had fallen by 45% since 1990 and the TB prevalence rate had fallen by 41% since 1990. To achieve the Stop TB Partnership targets of halving TB mortality and prevalence rates by 2015 compared with a baseline of 1990, an acceleration in the current rates of decline is required.

The Region of the Americas and the Western Pacific Region have already met the three 2015 targets for reductions in TB disease burden; the South-East Asia Region appears on track to do so. The other three regions are unlikely to meet the 2015 targets, although incidence, prevalence and mortality rates are falling. Among the 22 high burden countries (HBCs) that account for over 80% of the world’s TB cases, 10 appear on track to achieve all three global targets.

Between 2000 and 2013, TB diagnostic and treatment interventions saved an estimated 37 million lives.

Although most TB cases and deaths occur among men, the burden of disease is also high among women. In 2013, an estimated 510,000 women died from TB (330,000 among HIV-negative women and 180,000 among HIV-positive women). An estimated 80,000 HIV-negative children died from TB (estimates for HIV-positive children are not yet available).
periodically reviewed by an expert group and details are provided in an online technical appendix. Estimates of the number of incident TB cases among people living with HIV, the number of incident cases of MDR-TB, mortality due to MDR-TB and TB deaths disaggregated by HIV status are included in the relevant sections. Estimates are presented globally, for the six WHO Regions, and at country level with particular focus on the 22 HBCs. In response to increasing demand and global attention to maternal and child health, special consideration is given to estimates of TB disease burden among women and children.

A summary of key updates to data sources and methods used to produce the estimates of TB disease burden presented in this chapter compared with those used in 2013, and associated results, is provided in Box 2.1. Among these, the results from the first-ever survey of the national prevalence of TB disease in Nigeria have affected global estimates of TB burden. The main findings and programmatic implications of this survey are highlighted in Box 2.2.

There is uncertainty in all estimates of the burden of disease caused by TB, whether published by WHO or other sources. The final section of the chapter (Section 2.4) profiles efforts to improve measurement of the burden of disease caused by TB under the umbrella of the WHO Global Task Force on TB Impact Measurement. The recent and unprecedented progress in implementing national TB prevalence surveys is described and expanding efforts to strengthen surveillance of cases and deaths via notification and vital registration (VR) systems are discussed. Section 2.4 also includes a comparison of the latest WHO estimates contained in this report with other estimates that were published in peer-reviewed journals in 2014.

2.1 TB incidence

TB incidence has never been measured at national level because this would require long-term studies among large cohorts of people (hundreds of thousands), involving high costs and challenging logistics. Notifications of TB cases provide a good proxy indication of TB incidence in countries that have both high-performance surveillance systems (for example, there is little underreporting of diagnosed cases) and where the quality of and access to health care means that few cases are not diagnosed. In the large number of countries where these criteria are not yet met, better estimates of TB incidence can be obtained from an inventory study (an inventory study is a survey to quantify the level of underreporting). To date, such studies have been undertaken in only a few countries: examples include Egypt, Iraq, Pakistan and Yemen (see section 2.4).

The ultimate goal is to directly measure TB incidence from TB notifications in all countries. This requires a combination of strengthened surveillance, better quantification of underreporting (i.e. the number of cases that are missed by surveillance systems) and universal access to health care. A TB surveillance checklist developed by the WHO Global Task Force on TB Impact Measurement defines the standards that need to be met for notification data to provide a direct measure of TB incidence (further details in section 2.4).

For most countries, incidence estimates are currently based on notification data combined with country consultations in which in-depth analyses of the available surveillance, survey and programmatic data are undertaken, and expert opinion about the fraction of cases diagnosed but not reported, or not diagnosed at all, is elicited and documented. The 96 countries (with 89% of estimated TB cases) covered by such consultations since 2008 are shown in Figure 2.1. For remaining countries not covered in workshops and in which notifications do not provide a good proxy indication of TB incidence, estimates are based on extending previously published time series, mortality data from VR systems combined with evidence about the case fatality rate, or ecological modelling (details are provided in the online technical appendix).

In 2013, there were an estimated 9.0 million incident cases of TB (range, 8.6 million–9.4 million) globally, equivalent to 126 cases per 100 000 population (Table 2.1, Table 2.2). The absolute number of incident cases is falling slowly (Figure 2.2), at an average rate of 1.5% per year 2000–2013 and 0.6% between 2012 and 2013. Most of the estimated number of cases in 2013 occurred in Asia (56%) and the African Region (29%); smaller proportions of cases occurred in the Eastern Mediterranean Region (8%), the European Region (4%) and the Region of the Americas (3%). The 22 HBCs that have been given highest priority at the global level since 2000 (listed in Table 2.1 and Table 2.2) accounted for 82% of all estimated incident cases worldwide. The six countries that stand out as having the largest number of incident cases in 2013 were India (2.0 million–2.3 million), China (0.9 million–1.1 million), Nigeria (340 000–880 000), Pakistan (370 000–650 000), Indonesia (410 000–520 000) and South Africa (410 000–520 000); these and the other five countries that make up the top ten in terms of numbers of cases are highlighted in Figure 2.3. India and China alone accounted for 24% and 11% of global cases, respectively. Of the 9.0 million incident cases, an estimated 550 000 were children and 3.3 million (range, 3.2–3.5 million) occurred among women (Box 2.3).

The 9.0 million incident TB cases in 2013 included 1.0 million–1.2 million (11–14%) among people living with

1 The online technical appendix is available at www.who.int/tb/publications/inventory_studies/en/index.html.
2 Inventory studies can be used to measure the number of cases that are diagnosed but not reported. If certain conditions are met, results can also be used to estimate TB incidence using capture-recapture methods. A guide on inventory studies is available at: www.who.int/tb/publications/inventory_studies/en/index.html.
3 Asia refers to the WHO Regions of South-East Asia and the Western Pacific.
Updates to estimates of TB disease burden in this report and updates that are anticipated in the near future

Each year, new data become available for the estimation of TB disease burden. Periodically, methods for using surveillance and survey data as well as other sources of information to estimate TB disease burden are reviewed and updated. This box provides a summary of updates that were made in 2014. Updates for specific countries that are expected in the near future, pending the finalization of results from recently completed national prevalence surveys, are also highlighted.

Updates in this report

1. Updates based on new data from national TB prevalence surveys

At the end of 2013, final results became available from national TB prevalence surveys implemented between 2011 and 2013 in five countries: Gambia, Lao PDR, Nigeria, Pakistan and Rwanda. Survey results have been used to update estimates of TB burden in these countries (Figure 2.1.1; this also shows results for five other countries where surveys were implemented between 2007 and 2010). In Pakistan and Rwanda, updated estimates are similar to those published in previous global TB reports. In the Gambia, burden estimates have been revised downwards. In Lao PDR and Nigeria, burden estimates have been revised upwards. In Nigeria, the best estimate of the burden of prevalent TB based on survey results is approximately two times higher than the previous estimate. Given the size of Nigeria’s population and TB burden, this upward revision in burden estimates affects global estimates of the absolute number of TB cases and deaths (but not overall global trends).

2. Expanded use of the Spectrum software programme

For the first time in 2013, estimates of TB incidence among people living with HIV and TB mortality among HIV-positive people were generated using the Spectrum software programme. Spectrum has been used for more than a decade to produce estimates of the burden of disease caused by HIV, to build projections about the future course of the HIV epidemic and to assess the potential impact of TB prevention and treatment interventions. A TB module was developed in 2012 and 2013 through a collaboration among the Futures Institute, the TB Modelling and Analysis Consortium (TB-MAC) hosted at the London School of Hygiene and Tropical Medicine, UNAIDS and WHO. In 2014, the use of Spectrum was expanded to generate not only estimates of HIV-positive TB incidence and mortality but also indirect estimates of HIV-negative TB mortality for countries without VR or mortality survey data. Details are provided in the online technical appendix.

3. Newly reported data

There are some relatively small changes to estimates of TB incidence, mortality and prevalence for many countries that reflect newly-reported data reported to WHO between mid-2013 and mid-2014, updated WHO estimates of the total number of deaths from all causes (that provide overall mortality envelopes), updates to estimates of the burden of HIV-associated TB and new TB notification data including corrections made to historical data. In most instances, changes are well within the uncertainty intervals of previously published estimates of TB burden and time trends are generally consistent. Newly-reported data are the reason for small changes to estimates of the number of TB deaths among women and children and to the number of incident MDR-TB cases.

4. In-depth epidemiological reviews

Updates to burden estimates have drawn on new analyses undertaken as part of in-depth epidemiological reviews. These have increased in frequency since 2013, linked to the requirements of the Global Fund’s new funding model. Epidemiological reviews are also helping to identify performance gaps in TB surveillance and form the basis of detailed and costed monitoring and evaluation plans.

Updates anticipated in the near future

Updates to estimates of disease burden are expected in several countries that have recently completed or will soon complete national TB prevalence surveys. These include: Ghana, Indonesia, Malawi, Mongolia, Sudan, the United Republic of Tanzania, Thailand, Zambia and Zimbabwe. Future updates will be made available in online country profiles and associated data sets. It is anticipated that updated estimates for Indonesia will have an impact on global estimates.

There is increasing country interest in inventory studies to directly measure under-reporting of cases (i.e. the number of cases that is detected but not reported to NTPs). If such studies are implemented, they may result in updates to estimates of TB burden, especially TB incidence.

In early 2015, following extensive preparations, a thorough review of the current epidemiological and modeling methods used to estimate TB disease burden will be conducted by an expert group convened by the WHO Global Task Force on TB Impact Measurement (see also section 2.4). The recommendations may result in some further updates in the 2015 global TB report.

http://www.futuresinstitute.org/spectrum.aspx
The first-ever national TB prevalence survey in Nigeria: main results and their implications

The first-ever national survey of the prevalence of TB disease in Nigeria was implemented in 2012, under the leadership of the National TB and Leprosy Control Programme (NTLCP). The main objective of the survey was to estimate the prevalence of pulmonary TB (bacteriologically confirmed i.e. sputum smear and/or culture positive) among the general population aged ≥15 years old.

Methods and main results

Survey design and overall methods followed the international recommendations of the WHO Global Task Force on TB Impact Measurement. All survey participants were screened for symptoms by interview and by chest X-ray examination. Participants with any current symptom suggestive of TB or radiological lesion(s) in the lung were requested to submit two sputum specimens (one spot and one early-morning) that were examined by microscopy (AFB) and culture (LJ solid media) in one of three laboratories – the Nigeria Institute of Medical Research (NMIR), the National Tuberculosis and Leprosy Training Centre (NTBLTC), and the Zankli Medical Centre in Abuja.

A total of 113 247 people of all ages were enumerated during the survey, which covered 70 randomly selected clusters. Of these, 77 797 (69%) were eligible and invited to participate in the survey based on age (≥15 years old) and residency status (residents were defined as having slept in the household for 14 days or more at the day of the survey census). Of those who were eligible, 44 186 persons (57%) participated in the survey’s cluster operations, and of these 4 688 (10.6%) screened positive for TB (based on reported symptoms and/or chest X-ray result) and submitted at least one sputum specimen for bacteriological examination (Figure B2.2.1). The average number of participants per cluster was 631 (with a range of 279–819). Female participation was higher (59%) compared with male participation (41%) (Figure B2.2.2).

Among participants whose sputum specimens were processed, there were 107 smear-positive TB and 37 smear-negative/culture-positive TB cases, giving a total of 144 bacteriologically confirmed pulmonary TB cases. Among the 107 smear-positive TB cases, 80 (75%) reported TB symptoms during the screening process and 94 (88%) had a positive chest X-ray. Of the 144 bacteriologically confirmed cases, 92 (64%) reported TB symptoms during the screening process and 128 (89%) had a positive chest X-ray.

The crude prevalence of smear-positive TB among participants aged 15 years or older was 256 per 100 000 population (95% CI: 178–333) while the case notification rate of smear-positive TB cases (2012) in this age group was approximately 50 per 100 000 population, giving a prevalence:notification (P:N) ratio of 5.

Best-practice analytical methods were used to estimate TB prevalence accounting for clustered sampling, as well as non-participation and other missing data. TB prevalence rates per 100 000 population aged ≥15 years old were estimated to be 318 (95% CI: 225–412) for smear-positive TB, and 524 (95% CI: 378–670) for bacteriologically confirmed TB. Smear-positive TB prevalence among men was 484 (95% CI: 333–635) per 100 000 population, and 198 (95% CI: 108–289) per 100 000 population among women (Figure B2.2.3). For bacteriologically confirmed TB, the figures were 751 (95% CI: 538–965) and 359 (95% CI: 213–505) per 100 000 for men and women, respectively. An age differential in TB prevalence was also observed, with the highest burden of disease among the those aged 35–54 years old i.e. the most economically productive age groups.
The prevalence of TB disease varied geographically, and was considerably higher in urban compared with rural areas (Figure B2.2.4).

A total of 82 survey participants (0.2%) reported being on TB treatment at the time of the survey (37 men and 45 women, with 39 residing in urban areas). There were 552 (1.2%) survey participants who reported a past history of TB treatment (281 men and 271 women). Most of these people reported taking treatment in general hospitals (49%), followed by health centres/primary health centres (22%), teaching hospitals (11%), and private hospitals (10%). Only one person reported taking treatment at a pharmacy.

Lessons learned and programmatic implications

Notwithstanding the challenges of a low participation rate along with issues of security in some districts, the survey results are of high quality and have contributed towards a much better understanding and robust measurement of the burden of TB disease in Nigeria.

Amongst all national TB prevalence surveys since 2001 (data not shown), Nigeria has the highest prevalence to annual case notification ratio, at approximately 5 to 1. Such a high ratio was typically observed in national TB prevalence surveys in Asia before TB diagnostic and treatment services had been fully expanded and decentralized to the lowest levels of the health system. The high proportion (75%) of prevalent smear-positive cases in the community that reported typical TB symptoms also shows that TB diagnostic and treatment services of high quality still need to be made more accessible. Building on the past decade of efforts by the NTLCP and its partners to improve TB diagnosis and treatment, further strengthening and decentralization of TB diagnostic and treatment services are required. This should lead to a reduction in the proportion of prevalent cases that report TB symptoms. The geographical variation in the burden of disease also suggests that intensified case finding activities are a particular priority in urban slum areas.

Implications of survey results for national, regional and global estimates of TB disease burden

Results from the national TB prevalence survey in Nigeria have provided a robust direct measurement of TB disease burden in the country for the first time. Before survey results became available, indirect estimates of TB disease burden were calculated based mainly on reported TB case notification data and expert opinion about the levels of underreporting and underdiagnosis of cases. Case notification data were known to underestimate the true burden due to recognized problems with case detection. Based on the new prevalence survey results, burden estimates have been updated (see also Box 2.1) not only for prevalence (with appropriate adjustments for children and extra-pulmonary TB) but also for incidence (indirectly estimated from prevalence using plausible distributions of disease duration) and mortality (indirectly estimated from prevalence using case fatality ratios estimated from literature reviews). More details are provided in the online technical appendix. These updates have resulted in large upward revisions to estimates of TB disease burden in Nigeria.
Nigeria (Figure B2.2.5). Compared with the previously published best estimates for 2012, the new estimates in this report are 200% higher for incidence, 100% higher for prevalence and 400% higher for mortality (the greater impact on estimated mortality is due to the larger than previously estimated number of untreated cases). The estimated case detection rate (notifications of new and relapse cases divided by estimated incidence) has also decreased and the estimate for 2013 is 16% (95% uncertainty interval 11–30%).

Due to the size of the country’s population, these increases to estimates of TB disease burden in Nigeria also affect global estimates and estimates for the African Region. TB mortality in the African Region in 2013 is now estimated to be 44% higher than the previously published estimate for 2012. Global estimates of the absolute number of TB cases and deaths have also been revised upwards.


**TABLE 2.1**

Estimated epidemiological burden of TB, 2013. Best estimates are followed by the lower and upper bounds of the 95% uncertainty interval. Numbers in thousands

<table>
<thead>
<tr>
<th>POPULATION</th>
<th>MORTALITYa</th>
<th>HIV-POSITIVE TB MORTALITY</th>
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<th>INCIDENCE</th>
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<td>Afghanistan</td>
<td>30 552</td>
<td>13</td>
<td>&lt;0.1</td>
<td>0.2</td>
<td>0.2–0.2</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>156 595</td>
<td>80</td>
<td>0.2–0.2</td>
<td>350</td>
<td>310–400</td>
</tr>
<tr>
<td>Brazil</td>
<td>200 362</td>
<td>4.4</td>
<td>1.5–2.7</td>
<td>110</td>
<td>93–200</td>
</tr>
<tr>
<td>Cambodia</td>
<td>15 135</td>
<td>10</td>
<td>0.6–0.8</td>
<td>110</td>
<td>91–130</td>
</tr>
<tr>
<td>China</td>
<td>1 385 567</td>
<td>41</td>
<td>0.2–1.3</td>
<td>1 300</td>
<td>1 100–1 500</td>
</tr>
<tr>
<td>DR Congo</td>
<td>67 514</td>
<td>46</td>
<td>6.4–2.4</td>
<td>370</td>
<td>190–610</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>94 101</td>
<td>30</td>
<td>5.6–3.6</td>
<td>200</td>
<td>160–240</td>
</tr>
<tr>
<td>India</td>
<td>1 254 140</td>
<td>240</td>
<td>31–44</td>
<td>2 600</td>
<td>1 800–3 700</td>
</tr>
<tr>
<td>Indonesia</td>
<td>249 866</td>
<td>64</td>
<td>3.9–2.2–6.2</td>
<td>680</td>
<td>340–1 100</td>
</tr>
<tr>
<td>Kenya</td>
<td>44 354</td>
<td>9.1</td>
<td>5.5–12</td>
<td>130</td>
<td>90–200</td>
</tr>
<tr>
<td>Mozambique</td>
<td>25 834</td>
<td>18</td>
<td>3.4–2.6</td>
<td>140</td>
<td>28–73</td>
</tr>
<tr>
<td>Myanmar</td>
<td>53 259</td>
<td>26</td>
<td>4.3–3.3</td>
<td>250</td>
<td>190–320</td>
</tr>
<tr>
<td>Nigeria</td>
<td>73 615</td>
<td>160</td>
<td>85–47–140</td>
<td>570</td>
<td>430–730</td>
</tr>
<tr>
<td>Pakistan</td>
<td>182 143</td>
<td>100</td>
<td>1.0–0.5</td>
<td>620</td>
<td>520–740</td>
</tr>
<tr>
<td>Philippines</td>
<td>98 394</td>
<td>27</td>
<td>25–29</td>
<td>430</td>
<td>380–490</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>142 834</td>
<td>17</td>
<td>1.4–1.0–1.9</td>
<td>160</td>
<td>74–290</td>
</tr>
<tr>
<td>South Africa</td>
<td>52 776</td>
<td>25</td>
<td>15–38</td>
<td>380</td>
<td>210–590</td>
</tr>
<tr>
<td>Thailand</td>
<td>67 011</td>
<td>8.1</td>
<td>4.9–12</td>
<td>100</td>
<td>48–170</td>
</tr>
<tr>
<td>Uganda</td>
<td>37 579</td>
<td>4.1</td>
<td>2.2–6.6</td>
<td>72</td>
<td>5.0–9.9</td>
</tr>
<tr>
<td>Ur Tanzania</td>
<td>49 253</td>
<td>6.0</td>
<td>3.4–8.1</td>
<td>85</td>
<td>45–140</td>
</tr>
<tr>
<td>Viet Nam</td>
<td>91 680</td>
<td>17</td>
<td>12–24</td>
<td>190</td>
<td>79–350</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>14 150</td>
<td>5.7</td>
<td>3.6–7.4</td>
<td>58</td>
<td>33–89</td>
</tr>
<tr>
<td>High-burden countries</td>
<td>4 484 710</td>
<td>960</td>
<td>810–1 100</td>
<td>300</td>
<td>250–350</td>
</tr>
<tr>
<td>AFR</td>
<td>927 371</td>
<td>390</td>
<td>300–500</td>
<td>300</td>
<td>250–350</td>
</tr>
<tr>
<td>AMR</td>
<td>970 821</td>
<td>14</td>
<td>12–17</td>
<td>6.1</td>
<td>5.5–6.8</td>
</tr>
<tr>
<td>EUR</td>
<td>616 906</td>
<td>140</td>
<td>90–210</td>
<td>1.8</td>
<td>1.3–2.4</td>
</tr>
<tr>
<td>EUR</td>
<td>907 053</td>
<td>38</td>
<td>37–39</td>
<td>3.8</td>
<td>3.2–4.4</td>
</tr>
<tr>
<td>SEAR</td>
<td>1 855 068</td>
<td>440</td>
<td>330–550</td>
<td>48</td>
<td>42–55</td>
</tr>
<tr>
<td>WPR</td>
<td>1 858 410</td>
<td>110</td>
<td>100–120</td>
<td>4.8</td>
<td>3.7–5.9</td>
</tr>
<tr>
<td>Global</td>
<td>7 135 628</td>
<td>1 100</td>
<td>980–1 300</td>
<td>360</td>
<td>310–410</td>
</tr>
</tbody>
</table>

**Notes:**
- Numbers for mortality, prevalence and incidence shown to two significant figures. Totals (HBCs, regional and global) are computed prior to rounding.
- Mortality excludes deaths among HIV-positive TB cases. Deaths among HIV-positive TB cases are classified as HIV deaths according to ICD-10 and are shown separately in this table.
- Estimates of TB disease burden have not been approved by the national TB programme in Bangladesh and a joint reassessment will be undertaken following completion of the prevalence survey planned for 2015.
- Estimates for India have not yet been officially approved by the Ministry of Health & Family Welfare, Government of India, and should therefore be considered provisional.
- As this report went to press, estimates for Indonesia were being revised based on the results of the 2013–2014 national TB prevalence survey. Updated estimates will be published online. See also Box 2.1.

HIV, with a best estimate of 1.1 million (13%) (Table 2.1, Table 2.2). The proportion of TB cases co-infected with HIV was highest in countries in the African Region (Figure 2.4). Overall, 34% of TB cases were estimated to be co-infected with HIV in this region, which accounted for 78% of TB cases among people living with HIV worldwide. In parts of southern Africa, more than 50% of TB cases were co-infected with HIV (Figure 2.4).

Following a systematic review of evidence about mortality caused by MDR-TB undertaken in 2013 (featured in the 2013 global TB report) and consensus about what indicators to use for reporting on the burden of MDR-TB (Chapter 5, Box 5.3), this report includes updated global estimates of MDR-TB incidence and mortality. The best estimate is that there were 480 000 (range, 350 000–610 000) new cases of MDR-TB worldwide in 2013. This total includes cases of primary and acquired MDR-TB.

The number of incident TB cases relative to population size (the incidence rate) varies widely among countries (Figure 2.5). The lowest rates are found predominantly in high-income countries including most countries in western Europe, Canada, the United States of America,
The burden of TB disease among women and children

With increasing global attention to maternal and child health, there has been growing demand for and interest in estimates of TB disease burden among women and children. Estimates of the global burden of TB disease among children (defined as people aged <15 years) have been published in this report since 2012 and this is the second year in which the report includes estimates of the burden among women (defined as females aged ≥15 years) disaggregated by WHO region and HIV status.

There were an estimated 3.3 million new cases of TB and 510 000 deaths from the disease among women in 2013. Among children, there were an estimated 550 000 new cases in 2013 and 80 000 deaths among children who were HIV-negative. The estimates of TB morbidity and mortality among women are slightly higher than those published in the 2013 global TB report, due to upward revisions in estimates of the total number of incident TB cases and TB deaths (Box 2.1). The estimates of TB morbidity and mortality among children are slightly higher than those published in the 2013 global TB report, reflecting the use of an ensemble approach to combine two different independent calculations of incidence among children globally, and new VR data. Methods used to produce these estimates and further details about results are provided below.

The burden of TB in women: estimates of TB incidence and mortality, 2013

Incidence

Regional estimates of the women:men ratio for new and relapse TB case notifications in 2013 were generated and assumed to be the same as the ratio among incident TB cases in 2013 (see online technical appendix for further details). The resulting global and regional estimates of incidence are shown in Table B2.3.1. Women account for 31% of the total of 9.0 million incident cases in 2013. The African and South-East Asia regions account for 69% of the cases among women.

<table>
<thead>
<tr>
<th>WHO REGION</th>
<th>NUMBER OF TB CASE NOTIFICATIONS AMONG WOMEN</th>
<th>ESTIMATED TB INCIDENCE AMONG WOMEN</th>
<th>BEST ESTIMATE</th>
<th>UNCERTAINTY INTERVAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFR</td>
<td>390 808</td>
<td>990 000</td>
<td>880 000–1 100 000</td>
<td></td>
</tr>
<tr>
<td>AMR</td>
<td>73 905</td>
<td>100 000</td>
<td>96 000–110 000</td>
<td></td>
</tr>
<tr>
<td>EMR</td>
<td>180 917</td>
<td>330 000</td>
<td>270 000–390 000</td>
<td></td>
</tr>
<tr>
<td>EUR</td>
<td>84 508</td>
<td>120 000</td>
<td>110 000–130 000</td>
<td></td>
</tr>
<tr>
<td>SEAR</td>
<td>234 190</td>
<td>1 300 000</td>
<td>1 200 000–1 400 000</td>
<td></td>
</tr>
<tr>
<td>WPR</td>
<td>346 537</td>
<td>510 000</td>
<td>480 000–530 000</td>
<td></td>
</tr>
<tr>
<td>Global</td>
<td>1 310 865</td>
<td>3 300 000</td>
<td>3 200 000–3 500 000</td>
<td></td>
</tr>
</tbody>
</table>

Mortality

In total, there were an estimated 510 000 TB deaths among women in 2013. This includes 330 000 (range, 290 000–380 000) TB deaths among HIV-negative women (30% of all TB deaths among HIV-negative adults) and 180 000 (range, 160 000–210 000) HIV-associated TB deaths (50% of all HIV-associated TB deaths). Newly reported data and upward revisions to the total estimated number of TB deaths (Box 2.1) are the reason why numbers are higher compared with those published in 2013.

Mortality data disaggregated by age and sex from VR systems were used to produce estimates of TB deaths among HIV-negative adults for 111 countries. TB deaths were calculated for women and men, after adjustment for incomplete coverage and ill-defined causes (see online technical appendix for further details). For countries without VR data, the ratio of the adjusted male:female number of deaths due to TB was estimated using an imputation model that included risk factors known to be associated with TB mortality. Globally, there were an estimated 2.14 (range, 1.56–2.73) male deaths among HIV-negative adults for every female death (Figure B2.3.1). Regional differences are evident (Table B2.3.2), with the African and South-East Asia regions accounting for 73% of total deaths. The main limitation in the methods used is that the 111 countries reporting usable VR data were all middle- or high-income countries. Predictions for low-income countries had to be extrapolated from these countries.

TB deaths among HIV-positive people were disaggregated by sex using the assumption that the male to female sex ratio is similar to the sex ratio of AIDS deaths estimated by UNAIDS. Globally, the numbers of HIV-associated TB deaths were similar among men and women (Figure B2.3.2). However, there were striking regional variations (Table B2.3.2). In the African Region, more deaths occurred among women than men, while in other regions more deaths were estimated to have occurred among men.

<table>
<thead>
<tr>
<th>REGION</th>
<th>HIV-NEGATIVE BEST ESTIMATE</th>
<th>HIV-NEGATIVE UNCERTAINTY INTERVAL</th>
<th>HIV-POSITIVE BEST ESTIMATE</th>
<th>HIV-POSITIVE UNCERTAINTY INTERVAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFR</td>
<td>110 000</td>
<td>79 000–130 000</td>
<td>160 000</td>
<td>140 000–190 000</td>
</tr>
<tr>
<td>AMR</td>
<td>4 300</td>
<td>3 600–5 000</td>
<td>2 100</td>
<td>1 900–2 300</td>
</tr>
<tr>
<td>EMR</td>
<td>44 000</td>
<td>33 000–54 000</td>
<td>990</td>
<td>840–1 200</td>
</tr>
<tr>
<td>EUR</td>
<td>11 000</td>
<td>10 000–11 000</td>
<td>990</td>
<td>850–1 100</td>
</tr>
<tr>
<td>SEAR</td>
<td>130 000</td>
<td>100 000–170 000</td>
<td>17 000</td>
<td>14 000–20 000</td>
</tr>
<tr>
<td>WPR</td>
<td>36 000</td>
<td>33 000–39 000</td>
<td>1 200</td>
<td>1 000–1 400</td>
</tr>
<tr>
<td>Global</td>
<td>330 000</td>
<td>290 000–380 000</td>
<td>180 000</td>
<td>160 000–210 000</td>
</tr>
</tbody>
</table>

The burden of TB in children: estimates of TB notifications, incidence and mortality (among those HIV-negative), 2013

A global consultation on estimates of TB disease burden among children was held in September 2013. Outcomes of the consultation included the further development of analytical methods, strengthening of collaboration between WHO and research groups and the definition and prioritization of actions needed to obtain more and better data.

TB notifications and incidence

Among countries that reported age-disaggregated notification data for 2013 (Figure B2.3.3), the total number of new and relapse cases among children was 275 000. Compared with 2012, fewer cases were notified in India (about 15 000 less) and the Democratic Republic of the Congo (about 10 000 less). For countries that did not report age-disaggregated data, the ratio of child to adult notified cases was assumed to be the same as in those countries that did report notifications disaggregated by age. The estimated global number of TB case notifications among chil-
In 2013, after accounting for countries that did not report age-disaggregated data, was 300 000.

To estimate TB incidence among children, an ensemble approach was used to combine results from two independent methods (see online technical appendix for further details). The first method calculated child:adult ratios for new and relapse TB case notifications in 2013 and assumed those to be the same as the ratio among incident TB cases in 2013. These ratios were then used to disaggregate global TB incidence among children and adults. The second method was a mechanistic mathematical model, which estimated incidence in children using adult TB prevalence estimates and parameters related to the natural history of paediatric TB. The resulting estimate of global TB incidence among children in 2013, based on the combination of findings from two independent methods, is 550 000 (range, 470 000–640 000), equivalent to about 6% of the total number of 9.0 million incident cases.

Limitations of the methods used include:
- The assumption that reported cases were true cases of TB. Misdiagnosis is possible, especially given the difficulties of diagnosing TB in children.
- The assumption that the case detection rate is the same for adults and children, in the absence of any data on levels of underreporting of diagnosed cases for children and adults separately.
- The proportion of cases among children may be different in countries for which age-disaggregated data were not available. However, this is becoming less of a problem as the reporting of cases disaggregated by age has been improving and the number of countries not reporting age-disaggregated data was low in 2013 (Figure B2.3.3).

Mortality among HIV-negative children

Mortality data reported to WHO from VR systems that were disaggregated by age were available for 111 countries. These data were used to calculate TB death rates per 100 000 population for children and adults, after adjustment for incomplete coverage and ill-defined causes (see online technical appendix for further details). For countries without VR data, the adjusted child:adult ratio of the number of TB deaths was imputed using a model that included risk factors that are known to be associated with TB mortality. The estimated total number of deaths from TB among HIV-negative children in 2013 was 80 000 (range, 64 000–97 000), equivalent to about 7% of the total number of 1 100 000 TB deaths among HIV-negative people in 2013.

An estimate of TB mortality among HIV-positive children is not yet available, due to the difficulties arising from the miscoding of HIV deaths as TB deaths. Age-disaggregation of HIV-associated TB mortality will be one of the future outcomes of the TB component of Spectrum (Box 2.1).

Steps to improve estimation of TB cases among children include:
- Promotion of case-based electronic recording and reporting systems that facilitate compilation and analysis of age-disaggregated data;
- Nationwide inventory surveys to measure underreporting of childhood TB;
- More contact-tracing studies and the integration of TB activities in maternal, newborn and child health services to find childhood cases that might otherwise not be diagnosed.

a  In the updated recording and reporting framework issued by WHO in 2013 (Chapter 4), it is recommended that age-disaggregated data are reported for all new and relapse cases.

**TABLE 2.2**

Estimated epidemiological burden of TB, 2013. Best estimates are followed by the lower and upper bounds of the 95% uncertainty interval. Rates per 100 000 population except where indicated.

<table>
<thead>
<tr>
<th>POPULATION (THOUSANDS)</th>
<th>MORTALITY*</th>
<th>HIV-POSITIVE TB MORTALITY</th>
<th>PREVALENCE</th>
<th>INCIDENCE</th>
<th>HIV PREVALENCE IN INCIDENT TB CASES (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>30 552</td>
<td>42 27–53</td>
<td>0.3</td>
<td>0.2–0.3</td>
<td>340 178–554</td>
</tr>
<tr>
<td>Bangladesh b</td>
<td>156 595</td>
<td>51 33–69</td>
<td>0.1 &lt;0.1–0.2</td>
<td>402 210–656</td>
<td>224 199–253</td>
</tr>
<tr>
<td>Brazil</td>
<td>200 362</td>
<td>2.2 1.3–3.4</td>
<td>1.0 0.8–1.4</td>
<td>57 27–99</td>
<td>46 41–52</td>
</tr>
<tr>
<td>Cambodia</td>
<td>15 135</td>
<td>66 42–92</td>
<td>3.9 3.0–5.0</td>
<td>715 604–834</td>
<td>400 366–444</td>
</tr>
<tr>
<td>China</td>
<td>3 185 567</td>
<td>3.0 2.9–3.1</td>
<td>&lt;0.1 &lt;0.1–0.1</td>
<td>94 82–107</td>
<td>70 66–77</td>
</tr>
<tr>
<td>DR Congo</td>
<td>67 514</td>
<td>68 33–78</td>
<td>9.5 0.3–35</td>
<td>549 285–898</td>
<td>326 297–356</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>94 101</td>
<td>32 17–50</td>
<td>5.9 3.8–8.5</td>
<td>211 170–257</td>
<td>224 188–276</td>
</tr>
<tr>
<td>India c</td>
<td>1 252 140</td>
<td>19 12–28</td>
<td>3.0 2.5–3.5</td>
<td>211 143–294</td>
<td>171 162–184</td>
</tr>
<tr>
<td>Indonesia d</td>
<td>24 866</td>
<td>25 14–37</td>
<td>1.6 0.9–2.5</td>
<td>272 138–450</td>
<td>183 164–207</td>
</tr>
<tr>
<td>Myanmar</td>
<td>53 259</td>
<td>49 29–71</td>
<td>8.0 6.3–9.9</td>
<td>473 364–595</td>
<td>373 340–413</td>
</tr>
<tr>
<td>Pakistan</td>
<td>182 143</td>
<td>56 25–92</td>
<td>0.5 0.3–0.9</td>
<td>342 284–406</td>
<td>275 205–357</td>
</tr>
<tr>
<td>Philippines</td>
<td>98 394</td>
<td>27 25–29</td>
<td>&lt;0.1 &lt;0.1–0.1</td>
<td>438 385–495</td>
<td>292 261–331</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>142 834</td>
<td>12 12–13</td>
<td>1.0 0.7–1.3</td>
<td>114 51–201</td>
<td>89 82–100</td>
</tr>
<tr>
<td>South Africa</td>
<td>52 776</td>
<td>48 28–73</td>
<td>121 90–158</td>
<td>715 396–1130</td>
<td>860 776–980</td>
</tr>
<tr>
<td>Thailand</td>
<td>67 011</td>
<td>12 7.3–18</td>
<td>2.8 2.0–3.6</td>
<td>149 72–252</td>
<td>119 106–134</td>
</tr>
<tr>
<td>Uganda</td>
<td>37 579</td>
<td>11 5.8–18</td>
<td>19 13–26</td>
<td>154 85–243</td>
<td>166 149–193</td>
</tr>
<tr>
<td>Viet Nam</td>
<td>91 680</td>
<td>19 13–26</td>
<td>2.1 1.3–3.2</td>
<td>209 86–384</td>
<td>144 121–174</td>
</tr>
<tr>
<td>High-burden countries</td>
<td>4 484 710</td>
<td>21 18–25</td>
<td>6.7 5.6–7.9</td>
<td>208 183–235</td>
<td>165 158–173</td>
</tr>
<tr>
<td>AMR</td>
<td>970 821</td>
<td>1.5 1.2–1.7</td>
<td>0.6 0.6–0.7</td>
<td>38 30–48</td>
<td>29 28–31</td>
</tr>
<tr>
<td>EMR</td>
<td>616 906</td>
<td>23 15–34</td>
<td>0.3 0.2–0.4</td>
<td>165 143–189</td>
<td>121 100–144</td>
</tr>
<tr>
<td>EUR</td>
<td>907 053</td>
<td>4.1 4.0–4.2</td>
<td>0.4 0.4–0.5</td>
<td>51 39–65</td>
<td>39 38–41</td>
</tr>
<tr>
<td>SEAR</td>
<td>1 855 068</td>
<td>23 18–30</td>
<td>2.6 2.2–3.0</td>
<td>244 188–307</td>
<td>183 175–192</td>
</tr>
<tr>
<td>WPR</td>
<td>1 858 410</td>
<td>5.8 5.4–6.3</td>
<td>0.3 0.2–0.3</td>
<td>121 109–134</td>
<td>87 82–92</td>
</tr>
<tr>
<td>Global</td>
<td>7 135 628</td>
<td>16 14–18</td>
<td>5.0 4.3–5.8</td>
<td>159 143–176</td>
<td>126 121–131</td>
</tr>
</tbody>
</table>

* Mortality excludes deaths among HIV-positive TB cases. Deaths among HIV-positive TB cases are classified as HIV deaths according to ICD-10 and are shown separately in this table.

b Estimates of TB disease burden have not been approved by the national TB programme in Bangladesh and a joint reassessment will be undertaken following completion of the prevalence survey planned for 2015.

c Estimates for India have not yet been officially approved by the Ministry of Health & Family Welfare, Government of India, and should therefore be considered provisional.

d As this report went to press, estimates for Indonesia were being revised based on the results of the 2013–2014 national TB prevalence survey. Updated estimates will be published online. See also Box 2.1.

Japan, Australia and New Zealand. In these countries, the incidence rate is less than 10 cases per 100 000 population per year. Most countries in the Region of the Americas have rates below 50 per 100 000 population per year and this is the region with the lowest burden of TB on average. Most of the HBCs have rates of around 150‒300 cases per 100 000 population per year (Table 2.2); HBCs with markedly lower rates in 2013 were Brazil, China and the Russian Federation, while rates were above 500 per 100 000 population in Mozambique, South Africa and Zimbabwe. Other countries in the top ten worldwide in terms of incidence rates in 2013 were mostly in Africa (Figure 2.3). In Lesotho, South Africa and Swaziland, the best estimates suggest that about 1 person in every 100 (1000 per 100 000 population) develops active TB each year.

Globally, the incidence rate was relatively stable from 1990 up until around 2000, and then started to fall (Figure 2.6), achieving the MDG target ahead of the 2015 deadline. Between 2000 and 2013, the average rate of decline per year was 1.5%. This downward trend needs to be sustained to ensure that the MDG target is met in 2015. Incidence rates are also declining in all of six WHO...
regions (Figure 2.7), fastest in the European Region (4.5% per year) and slowest in the Eastern Mediterranean and South-East Asia Regions (less than 1% per year and 1.5% per year, respectively). Incidence rates have been falling since around 2000 in the South-East Asia Region; they peaked around 1999 in the European Region and around 2003 in the African region, and have been falling since 1990 in Eastern Mediterranean Region, the Region of the Americas and the Western Pacific Region. The latest assessment for the 22 HBCs suggests that incidence rates are falling in most countries (Figure 2.8).

2.2 TB prevalence

In countries with a relatively high burden of TB (around 100 cases per 100 000 population or more), the prevalence of bacteriologically confirmed pulmonary TB can be directly measured in nationwide population-based surveys using sample sizes of around 50 000 people. Survey results can be used to produce a national estimate of TB prevalence that includes all forms of TB. The cost of a survey usually ranges from US$ 1 to 4 million, and comprehensive theoretical and practical guidance on survey design, implementation, analysis and reporting of results...
FIGURE 2.5

Estimated TB incidence rates, 2013

FIGURE 2.6

is available.\(^1\) Repeat surveys conducted about every 10 years allow trends in disease burden to be assessed. HBCs that have completed repeat surveys in the last 10 years include Cambodia, China, the Philippines and Thailand. Repeat surveys are planned in Myanmar and Viet Nam around 2015, and a fourth survey is planned in the Philippines in 2015. Countries in which surveys have been implemented or are planned in the near future are shown in Figure 2.9. Between 2008 and 2016, an unprecedented number of national TB prevalence surveys have been or will be conducted (see also section 2.4).

In low- and medium-burden countries, sample sizes and costs for surveys become prohibitively large. If survey data are not available, prevalence can be indirectly estimated as the product of incidence and the average duration of disease, but with considerable uncertainty (see the online technical appendix). Without a survey, TB prevalence can be estimated only indirectly.

There were an estimated 11 million prevalent cases (range, 10 million–13 million) of TB in 2013 (Table 2.1), equivalent to 159 cases per 100 000 population (Table 2.2). By 2013, the prevalence rate had fallen 41% globally since 1990. Current forecasts suggest that the Stop TB Partnership target of halving TB prevalence by 2015 compared with a baseline of 1990 will not be met worldwide (Figure 2.6). Regionally, prevalence rates are declining in all six WHO regions (Figure 2.10). The Region of the Americas halved the 1990 level of TB prevalence by around 2005, well in advance of the target year of 2015, and the best estimate suggests that the Western Pacific Region achieved the 50% reduction target in 2012. Reaching the 50% reduction target by 2015 appears feasible in the South-East Asia Region. The target appears out of reach in the African, European and Eastern Mediterranean regions.

### 2.3 TB mortality

TB mortality among HIV-negative people can be directly measured using data from national VR systems, provided that these systems have high coverage and causes of death are accurately coded according to the latest revision of the International classification of diseases (ICD-10). Sample VR systems covering representative areas of the country (e.g. as in China) provide an interim solution. Mortality surveys can also be used to estimate deaths caused by TB. In 2013, most countries with a high burden of TB lacked national or sample VR systems and few had conducted mortality surveys. In the absence of VR systems or mortality surveys, TB mortality can be estimated as the product of TB incidence and the case fatality rate, or from ecological modelling based on mortality data from countries with VR systems. TB mortality among HIV-positive people is hard to measure even when VR systems are in place because deaths among HIV-positive people

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are coded as HIV deaths and contributory causes (such as TB) are often not reliably recorded. For this 2014 report, country-specific estimates of TB deaths among HIV-positive people were produced using the Spectrum software that has been used for HIV burden estimates for over a decade (Box 2.1).

Until 2008, WHO estimates of TB mortality used VR data for only three countries. This was substantially improved to 89 countries in 2009; however most of the data were from countries in the European Region and the Region of the Americas, which accounted for less than 10% of the world’s TB cases. In 2011, the first use of sample VR data from China and survey data from India enabled a further major improvement to estimates of TB mortality. For the current report, VR data of sufficient coverage and quality were available for 124 countries. Combined with survey data from India and Viet Nam, this means that estimates of TB mortality are based on direct measurements of TB mortality in 126 countries (shown in Figure 2.11). Collectively, these 126 countries account for 36% of the estimated number of TB deaths globally. The parts of the world where there are major gaps in the availability of VR data are the African Region and parts of the South-East Asia Region; in the latter, Indonesia is currently building a sample VR system.

There were an estimated 1.5 million TB deaths in 2013 (Table 2.1, Figure 2.2): 1.1 million among HIV-negative people and 360,000 among HIV-positive people (TB deaths among HIV-positive people are classified as HIV deaths in ICD-10). These deaths included 510,000 among women and 80,000 among children (Box 2.3). There were approximately 210,000 deaths from MDR-TB (range, 130,000–290,000).

Approximately 78% of total TB deaths and 73% of TB deaths among HIV-negative people occurred in the African and South-East Asia Regions in 2013. India and Nigeria accounted for about one-third of global TB deaths.

The number of TB deaths per 100,000 population averaged 15 globally in 2013 (Table 2.2) and 21 when TB deaths among HIV-positive people are included. There is considerable variation among countries (Figure 2.12), ranging from under 1 TB death per 100,000 population (examples include most countries in western Europe, Canada, the United States of America, Australia and New Zealand) to more than 40 deaths per 100,000 population in much of the African Region as well as three HBCs in Asia (Bangladesh, Cambodia and Myanmar) and the two HBCs in the Eastern Mediterranean Region (Afghanistan and Pakistan).

Globally, the mortality rate (excluding deaths among HIV-positive people)\(^1\) has fallen by 45% between 1990 and 2013. The current rate of decline will need to accelerate to reach the Stop TB Partnership target of a 50% reduction by 2015 (Figure 2.6).

Regionally, mortality rates are declining in all six WHO regions (Figure 2.13). The 2015 target has already been surpassed in the Region of the Americas (since 2004) and the Western Pacific Region (since 2002), and may have been reached in 2013 in the South-East Asia Region. The target appears out of reach in the other three regions, although rates are falling fast in the European Region. Mortality rates appear to be falling in most of the 22 HBCs (Figure 2.14), although there is considerable uncertainty about the level of and trends in mortality in some countries, especially Nigeria where mortality estimates are indirectly derived from incidence (see technical appendix) and Thailand where the quality of cause of death data available from the national VR system needs improvement.

Between 2000 and 2013, TB diagnostic and treatment interventions saved an estimated 37 million lives (Box 2.4).

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\(^1\) Trends in TB mortality rates are restricted to TB deaths among HIV-negative people, given that TB deaths among HIV-positive people are classified as HIV deaths in ICD-10.
FIGURE 2.10


FIGURE 2.11

Countries (in orange) for which TB mortality is estimated using measurements from vital registration systems (n=124) and/or mortality surveys (n=2, India and Viet Nam)
Estimates of lives saved by TB interventions, 2000–2013

In July 2014, the Global Fund convened an expert meeting to discuss methods for estimating the lives saved by HIV, TB and malaria interventions. This followed concerns about methods used previously. For TB, it was agreed that lives saved should be estimated with respect to a counterfactual scenario of no TB treatment and no ART for HIV-positive TB cases. For the counterfactual scenario, it was further agreed that the number of TB deaths each year should be calculated as the estimated number of incident TB cases among HIV-negative and HIV-positive people each year (as presented in this chapter) multiplied by the case fatality ratios (CFR) for HIV-negative and HIV-positive TB that would apply in the absence of treatment (Table B2.4.1). The number of lives saved is then the difference between the estimated actual number of TB deaths each year (as presented in this chapter) and the number of deaths that would have occurred in the absence of treatment.

| TABLE B2.4.1 |
| Case fatality ratios (CFRs) in the absence of treatment |
| TB CASES | CFR (RANGE) |
| HIV negative not on TB treatment | 0.43 (0.28–0.53) |
| HIV positive not on ART, not on TB treatment | 0.78 (0.65–0.94) |

Using these methods, globally an estimated 37 million lives were saved by TB prevention, diagnosis and treatment interventions 2000–2013 (Table B2.4.2).

TABLE B2.4.2

Cumulative lives saved by TB prevention, diagnosis and treatment interventions 2000–2013, globally and by WHO region (in millions). Best estimates are followed by uncertainty intervals.

<table>
<thead>
<tr>
<th>REGION</th>
<th>HIV-NEGATIVE</th>
<th>HIV-POSITIVE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFR</td>
<td>4.0</td>
<td>3.3–4.8</td>
<td>5.0</td>
</tr>
<tr>
<td>AMR</td>
<td>1.4</td>
<td>1.2–1.5</td>
<td>0.28</td>
</tr>
<tr>
<td>EMR</td>
<td>2.6</td>
<td>2.1–3.0</td>
<td>0.03</td>
</tr>
<tr>
<td>EUR</td>
<td>2.1</td>
<td>1.8–2.3</td>
<td>0.15</td>
</tr>
<tr>
<td>SEAR</td>
<td>11</td>
<td>9.7–13</td>
<td>1.0</td>
</tr>
<tr>
<td>WPR</td>
<td>8.7</td>
<td>7.9–9.6</td>
<td>0.14</td>
</tr>
<tr>
<td>Global</td>
<td>30</td>
<td>26–34</td>
<td>7.0</td>
</tr>
</tbody>
</table>

A limitation of these methods is that they do not account for the impact of TB interventions on TB incidence or the impact of ART on TB incidence. They also do not account for the downstream impact of TB treatment and other interventions on the level of TB transmission and the future number of TB infections, cases and deaths. Methods that can incorporate these impacts are in development.

2.4 Strengthening measurement of the burden of disease caused by TB: the WHO Global Task Force on TB Impact Measurement

The estimates of TB incidence, prevalence and mortality and their trends presented in sections 2.1–2.3 are based on the best available data and analytical methods, which are periodically reviewed by an expert group (Box 2.5). Nonetheless, there remains considerable scope to improve measurement of the burden and trends in TB disease. This final section of the chapter describes the latest status of efforts to improve measurement of the burden of disease caused by TB, under the umbrella of the WHO Global Task Force on TB Impact Measurement. This task force was established in 2006 and includes representatives from leading technical and financial partners and countries with a high burden of TB.¹

At its second meeting in December 2007, the Global Task Force on TB Impact Measurement defined three strategic areas of work:²

- strengthening surveillance towards the ultimate goal of direct measurement of incidence and mortality from notification and VR systems, respectively;
- conducting surveys of the prevalence of TB disease in a set of global focus countries that meet epidemiological and other relevant criteria; and
- periodic review and updating of the methods used to translate surveillance and survey data into estimates of TB incidence, prevalence and mortality.

In 2008 and 2009, methods were thoroughly reviewed and updated by an expert group convened by the task force. Updates were discussed and endorsed by the full task force in March 2010. Current methods are described in detail in the online technical appendix, and an updated review is planned in early 2015 (Box 2.1, Box 2.5). The following sections focus on the other two strategic areas of work: strengthened surveillance and national TB prevalence surveys. Further details are available on the task force’s web site.³

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1 Many countries with a high burden of TB are engaged in the work of the Task Force. Partners that are actively participating in the work of the Task Force include the Centers for Disease Control and Prevention in the USA, the European Centre for Disease Prevention and Control, the Global Fund, Public Health England, the KNCV Tuberculosis Foundation, the London School of Hygiene and Tropical Medicine in the UK, the Research Institute for Tuberculosis in Japan, the Union and the United States Agency for International Development (USAID).


3 www.who.int/tb/advisory_bodies/impact_measurement_taskforce
Trends in estimated TB mortality rates 1990–2013 and forecast TB mortality rates 2014–2015, 22 high-burden countries. Estimated TB mortality excludes TB deaths among HIV-positive people. The horizontal dashed lines represent the Stop TB Partnership target of a 50% reduction in the mortality rate by 2015 compared with 1990. The other dashed lines show projections up to 2015. Uncertainty is due to adjustments made to the mortality data from vital registration systems that were reported by countries (mortality data from vital registration systems are represented by the “x” symbol).

2.4.1 Strengthening surveillance

Reasons for uncertainty in current estimates of TB incidence include use of expert opinion about both the number of cases that are diagnosed but not reported to national surveillance systems and the number of cases that are not diagnosed at all (section 2.1). Major challenges in estimating TB mortality include the lack of VR systems of sufficient coverage and quality in many countries, notably in Africa and parts of Asia (Figure 2.11). The long-term goal of directly measuring the level of and trends in TB disease burden from routine surveillance data, using notification data to measure TB incidence and VR data to measure TB mortality, requires strengthened surveillance in many countries. Countries for which more robust estimates of mortality were available in 2013 are shown in Figure 2.11.

TB surveillance checklist of standards and benchmarks

Strengthening surveillance to move towards the goal of direct measurement of TB incidence and mortality requires a clear understanding of what a ‘model’ surveillance system should look like and a method for assessing the current performance of TB surveillance. Following considerable work in 2011 and 2012, a TB surveillance checklist that defines the standards and associated benchmarks that need to be met for a country’s notification and VR data to be used as a direct measure of TB incidence and mortality was developed. By July 2014, the checklist had been used by 21 countries (Figure 2.15) as the basis for identifying what standards are already met and the investments required to close remaining gaps (Box 2.6). These assessments have been undertaken in close collaboration with the Global Fund so that use of the checklist is integrated into the fund’s grant processes and findings can inform investments by the fund as well as national...
Comparison of estimates presented in this report with other TB burden estimates published in 2014

Background

Why WHO makes health estimates and general approach

The production and dissemination of health statistics for health action at the country, regional and global levels are core WHO activities mandated by all Member States in the WHO Constitution. WHO works closely with countries, partners and global experts to produce health statistics of the greatest possible accuracy.

For all diseases, periodic updates of global health estimates usually involve statistical modelling to overcome major gaps in country data availability and quality and to obtain comparable global, regional and country health statistics. Given that there are many options in statistical modelling in terms of type of model, assumptions and complexity, an important feature of WHO’s global health monitoring is its commitment to transparency and consensus. This is achieved in several ways. Technical advisory groups including independent academic experts provide methodological advice; there is a country consultation process which provides a platform for Member States to understand how estimates are derived; and methods including descriptions of input data sets and software are described so that others can reproduce analyses.

Why estimates produced by different agencies and research groups can differ

Estimates always have uncertainty and the fewer the number of quality data points, the greater the uncertainty. Different researchers can easily produce different estimates for the same country, region or globally and this has happened on many occasions. In recent years, the Institute for Health Metrics and Evaluation (IHME) at the University of Washington, USA has started to publish, mostly in the Lancet, estimates for many health indicators globally and for countries. Sometimes these estimates are very different from those produced by WHO and UN agencies. WHO reviews and, in cases where scientific rigour can be evaluated, may make use of methods and estimates developed by IHME and other organizations. For instance, the publication of the IHME Global Burden of Disease (GBD) 2010 Study in a special issue of The Lancet in 2012 led to consultations and exchange of data between WHO, UNAIDS, other agencies and their expert groups. Over the past few years, investigation into differences in estimates has led to improvements in data inputs and estimation methods used by IHME and UN agencies. In several areas there is convergence in terms of methods and results of the estimation modelling. In others, more work is needed to discuss data inputs, methods and discrepant results.

TB estimates published in 2014 by IHME and other academic research groups

In 2014, three studies that include estimates of TB disease burden were published. These are:


IHME compared with WHO estimates

IHME and WHO global estimates for TB incidence, prevalence and mortality in terms of absolute levels in 2013 and trends since 2000 are summarized in Table B.2.5.1. This shows:

- Estimates of TB prevalence are similar, with vastly overlapping uncertainty intervals. The WHO estimate suggests that rate of decline since 2000 is faster.
- Both IHME and WHO estimate that the TB incidence rate is falling. The WHO estimate suggests that the rate of decline is faster.
- The IHME and WHO estimates of the absolute level of TB incidence are different and uncertainty intervals do not overlap. The WHO estimates are higher.
- Both IHME and WHO estimate that the TB mortality rate is falling. The WHO estimate suggests that the rate of decline is faster.
- The IHME and WHO estimates of the absolute level of TB mortality in 2013 are different and uncertainty intervals have limited overlap. The WHO estimates are lower.

<table>
<thead>
<tr>
<th></th>
<th>IHME</th>
<th>WHO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidence rate in 2013 (per 100 000 population)</td>
<td>105 (102–108)</td>
<td>126 (121–131)</td>
</tr>
<tr>
<td>Annualized rate of change (2000–2013, %)</td>
<td>-0.69</td>
<td>-1.5</td>
</tr>
<tr>
<td>Mortality rate in 2013, excluding HIV (per 100 000 population)</td>
<td>19.2 (17.4 – 20.9)</td>
<td>15.9 (13.9 – 17.9)</td>
</tr>
<tr>
<td>Annualized rate of change (2000–2013, %)</td>
<td>-3.7</td>
<td>-4.4</td>
</tr>
<tr>
<td>Prevalence rate in 2013 (per 100 000 population)</td>
<td>168 (164–173)</td>
<td>159 (142–176)</td>
</tr>
<tr>
<td>Annualized rate of change (2000–2013, %)</td>
<td>-1.4</td>
<td>-3.7</td>
</tr>
</tbody>
</table>

Of note, the most recent IHME estimates have changed considerably from those published as part of the Global Burden of Disease 2010 study, suggesting that IHME has made important changes to their model specifications and that outputs are subject to some instability. In addition, IHME’s best estimate of global incidence in 2013 (around 7.5 million cases including cases in HIV-positive individuals) is surprisingly close to the number of detected cases reported by countries (nearly 6 million cases in 2013, see Chapter 4), given strong evidence of large gaps in reporting of detected cases in some countries with a very high burden of TB. For example, unpublished data from a recent prevalence survey in one state in India indicate that more than 30% of detected cases are not reported, which is consistent with result from a previous large-scale household study. In Pakistan, the IHME estimate of incidence (225 000 HIV-negative TB cases in 2013) does not reach the number of notified cases (289 000, including an estimated 1 500 HIV-positive cases) in the same year.
Estimates of TB incidence among children published by WHO and three independent academic groups

Between March and July 2014, three independent academic groups published estimates of TB incidence in children, all in the Lancet group of journals. These estimates vary from less than 200 000 new cases in 2013 (Murray et al.) to a best estimate of 970 000 new cases (uncertainty interval 937 877–1 055 414) in 2010. In between these two is an estimate that the median number of children who developed TB disease in the 22 HBCs was 650 977 (range, 424 871–983 118) in 2010. The large variation in these estimates illustrates the challenges of estimating the burden of TB in children, a group in which cases are more difficult to diagnose and are rarely bacteriologically confirmed. The WHO estimates presented in this report (Box 2.3) have drawn upon one of these sets of estimates, which was commissioned by WHO and used complementary methods (i.e. dynamic modelling as opposed to estimates built up from notification data). WHO is working with multiple partners to improve understanding of the disease burden among children, following a global consultation convened by WHO and the TB Alliance in September 2013.

Conclusion

Differences in estimates of TB disease burden should always be examined in the context of their published uncertainty range and gaps in underlying data. Better quality surveillance data with more complete coverage and global adoption of nationwide vital registration systems with standard cause of death data will result in convergence of estimates of TB burden produced by different institutions. WHO and partners are actively engaged in supporting national TB programmes’ efforts to improve the performance of their health information systems, as described in section 2.4 of this chapter.

In early 2015, a thorough review of the current epidemiological and modelling methods used by WHO to estimate TB disease burden will be conducted by an expert group convened by the WHO Global Task Force on TB Impact Measurement (see section 2.4), and updated as appropriate.


governments and other partners. With more than 100 low- and middle-income countries receiving TB grants from the Global Fund, this approach has great potential to make a real difference to TB surveillance worldwide. Assessments of TB surveillance using the checklist of standards and benchmarks is now part of the standard terms of reference for the “epidemiological stage” that is a prerequisite for applications to the Global Fund as part of its new funding model introduced in 2013.

Inventory studies to measure or estimate TB underreporting

One of the standards in the TB surveillance checklist is that all diagnosed cases of TB are reported to the national surveillance system. The two benchmarks that must be satisfied are: 1) that TB reporting is a legal requirement; and 2) that ≥90% of TB cases are reported to national health authorities, as determined by a national-level investigation such as an inventory study. To date, few countries have implemented an inventory study but as the number doing so increases, estimates of the level of and trend in TB incidence will improve. Even when underreporting is considerable and notification data are not a good proxy for TB incidence, results from inventory studies can be used to quantify the gap and obtain more precise estimates of disease burden and provide valuable information about where efforts to collaborate with public and private sector providers are needed. In 2012, the Global Task Force on TB Impact Measurement completed a guide on how to design and implement an inventory study, and how to analyse and report results.1

In the past 10 years, inventory studies combined with capture–recapture analysis have been implemented in the Netherlands, the UK, French Guiana, Egypt, Iraq, Pakistan and Yemen. A workshop to develop protocols for inventory studies in five HBCs (China, Indonesia, the Philippines, Thailand and Viet Nam) was held in Indonesia in September 2014.

Electronic recording and reporting of data

Several of the standards in the TB surveillance checklist are about data quality. In all of the regional and country workshops held between 2008 and 2013, it was evident that it is easier to assess the quality of TB surveillance data in countries with case-based electronic recording and reporting systems. Besides facilitating assessment of data quality, electronic recording and reporting systems have other major advantages compared to systems based solely on paper-based recording and reporting. These include:

- Better programme and resource management, by encouraging staff to use and act upon live data. This

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BOX 2.6

The checklist of standards and benchmarks for TB surveillance and vital registration systems: Progress to date

The ultimate goal of directly measuring TB incidence and mortality from notifications and vital registration systems respectively requires high-performing surveillance systems. The Checklist of standards and benchmarks for TB surveillance and vital registration systems (the checklist) was developed in 2011–2012 with two objectives:

- To assess a national surveillance system’s ability to accurately measure TB cases and deaths;
- To identify gaps in national surveillance systems that need to be addressed.

Results of assessments using the checklist can be used to identify which countries have surveillance systems that already provide an accurate measure of the burden of TB, and to define the actions necessary to strengthen surveillance in countries in which gaps are identified.

The Checklist contains standards that are general statements about the characteristics that define a high-performance TB surveillance system; nine standards are related to the measurement of TB cases and one is related to measurement of TB deaths. There are also three supplementary standards to assess whether a country’s TB surveillance system provides a direct measure of the number of drug resistant TB cases, HIV-positive TB cases, and childhood TB cases. For each of the thirteen standards, benchmarks define (in quantitative terms wherever possible) the level of performance considered sufficient to meet the respective standard. An accompanying user guide was developed to provide instructions to implement the checklist of standards and benchmarks in an accurate and standardised way. The rationale for each standard and associated benchmark(s), and the methods that should be used to assess the benchmarks, are explained in the user guide. Both the checklist and user guide are available for download: http://www.who.int/tb/publications/standardsandbenchmarks/en/

TABLE B2.6.1

Aggregated outcomes for 21 countries that undertook the Checklist

<table>
<thead>
<tr>
<th>THE STANDARDS</th>
<th>OUTCOMES*</th>
</tr>
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| 1.1 Case definitions are consistent with WHO guidelines                        | ⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚪⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫⚫intégral policy and programmatic management. A new handbook on understanding and using TB surveillance data has been developed to help address this challenge.a

- There was a limited understanding of the level of under-reporting of TB cases i.e. the number of TB cases that are detected but not reported to national surveillance systems. A formal examination of the level of under-reporting via inventory studies was frequently requested by many countries.

- The currently poor measurement of TB mortality calls for greater strengthening of vital registration systems and the appropriate coding of deaths in many countries.

FIGURE 2.15
Countries (in red) where the TB surveillance checklist of standards and benchmarks has been used: status in July 2014

FIGURE 2.16
Availability of national electronic case-based databases of TB patients, 2013
may help to prevent loss to follow up during treatment and assist with management of drug supplies (including avoidance of stock-outs).

- Improved surveillance by making it easier for facilities not traditionally linked to the NTP, such as hospitals, prisons and the private sector, to report TB cases, and by reducing the burden of compiling and submitting data through paper-based quarterly reports.
- Analysis and use of data is facilitated, since data can be readily imported into statistical packages. Results are then available to decision-makers more quickly and it is possible to detect outbreaks promptly.
- Higher quality data, since automated data quality checks can be used and duplicate or misclassified notifications can be identified and removed (which is very difficult or impossible to do nationally with paper-based systems). It is also easier to introduce new data items.
- Identification of clusters of cases in space and time, including clusters of drug-resistant cases, thus allowing early investigation and containment of epidemics.

Countries that have national electronic case-based databases of TB patients are shown in Figure 2.16. Recent guidance on electronic recording and reporting for TB care and control, developed by WHO and partners in 2011, is available on the task force’s website.\(^1\)

2.4.2 National surveys of the prevalence of TB disease

Before 2007, few countries had implemented nationwide prevalence surveys. In the 1990s, national surveys were confined to China, Myanmar, the Philippines and the Republic of Korea. Before 2009 and with the exception of Eritrea in 2005, the last national surveys in the African Region were undertaken between 1957 and 1961. From 2002 to 2008, there was typically one survey per year.

In 2007, WHO’s Global Task Force on TB Impact Measurement identified 53 countries that met epidemiological and other criteria for implementing a survey. A set of 22 global focus countries were selected to receive particular support in the years leading up to 2015. The African countries were: Ethiopia, Ghana, Kenya, Malawi, Mali, Mozambique, Nigeria, Rwanda, Sierra Leone, South Africa, Uganda, the United Republic of Tanzania and Zambia. Countries in Asia were: Bangladesh, Cambodia, China, Indonesia, Myanmar, Pakistan, the Philippines, Thailand and Viet Nam. Since early 2008, substantial efforts to support countries to design, implement, analyse and report on surveys have been made. Examples include development of updated guidance,\(^2\) coordination of technical assistance, expert reviews of protocols, organization of study tours and mid-term survey reviews, and global and regional workshops to support survey design and implementation and to share results and lessons learned among countries. As part of these efforts, the concept of Asia–Asia, Asia–Africa and Africa–Africa (‘AA’) collaboration has been strongly promoted.

Following six years of substantial effort at country, regional and global levels, unprecedented progress has been achieved (Figure 2.17). If surveys are implemented according to schedule, more than 20 surveys will be implemented between 2011 and 2015. Five national TB prevalence surveys had field operations completed in 2012 (Gambia, Nigeria, Rwanda, Thailand and the United Republic of Tanzania, two in 2013 (Ghana, Sudan) and a further three will be completed in 2014 (Indonesia, Malawi and Zambia). Field operations are systematically followed with lengthy data cleaning and validation before final results are disseminated. These surveys provide an unbiased estimation of disease burden, often for the first time, and contribute to better estimates of disease burden once results are finalized (Box 2.1). Surveys are also providing a rich source of data to inform programme policy and strategy. For several recent surveys, country-specific reports and peer-reviewed publications are already available (for example, from China,\(^3\) Cambodia,\(^4\) Ethiopia,\(^5\) Myanmar,\(^6\) and Pakistan\(^7\)) and others are in the pipeline.

Although some findings and lessons learned are country-specific, others are common to most surveys:

- Most of the prevalent TB cases in the community were not identified by classical symptom screening (i.e. a cough of more than 2–3 weeks duration and/or blood in the sputum) but rather by chest X-ray screening. This proportion tends to increase over time as programmatic and case management improve.
- In Asia, there is a progressive increase in the prevalence of TB with age. As transmission declines, levels of infection in younger age groups fall and the burden of

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7. The official report can be downloaded from here: http://www.tbcare1.org/countries/asia/pkn/
Figure 2.17

- Disease shifts to older age groups. This is reinforced by the demographic transition in these countries, which is associated with a general ageing of the population. The age distribution of cases in Africa is more mixed, with some countries (e.g. Gambia, Rwanda) having a pattern similar to that observed in Asia and others (e.g. Ethiopia, Nigeria) having a peak prevalence in younger age groups.
- Prevalence is much higher among men than women. The sex ratio (M:F) is typically between 2:1 and 3:1 in Asia. In Africa, more cases also occur among men.
- Comparison of the number of smear-positive prevalent cases of TB with equivalent notification data (P:N ratio) illustrates the extent to which NTPs are able to promptly detect and treat cases and variation in performance among countries. In countries such as Nigeria and Lao PDR, a relatively high P:N ratio indicates that there is considerable scope for further improvement in case detection using already available approaches to TB diagnosis and treatment and/or by improving reporting of detected cases.
- A smear-positive sputum result does not necessarily mean TB. Recent surveys have identified a considerable proportion of participants with smear-positive specimens who do not have clinical signs consistent with clinical TB, and culture results that are either negative or confirm non-tuberculous mycobacteria. For this reason, in the most recent surveys smear-positive specimens are being retested with GeneXpert MTB/RIF to ensure accurate diagnosis of cases for whom smear results and clinical findings are inconsistent as well as appropriate case management.
- Although most surveys are not designed to estimate prevalence at sub-national level, surveys often show considerable geographical variation in the level of TB prevalence. Therefore specific control activities for areas with a higher prevalence may need to be considered as part of national strategic plans.
- In surveyed countries with a generalized HIV epidemic, implementation of collaborative TB/HIV activities may help to reduce the overall prevalence of HIV among newly diagnosed TB cases. In Rwanda, for example, the prevalence of HIV among prevalent cases detected during the survey was much lower than the prevalence of HIV measured through routine testing of registered TB patients. This suggests that systematic screening of TB in people living with HIV and associated HIV care has had a positive impact.

Given the increasing availability of prevalence survey data, WHO is establishing a global data repository that will allow for the safe storage of summary results and a minimum set of anonymised individual-level data. Standard agreements and survey-specific access controls will be used to define access rights to stored data i.e. NTPs can decide for their own survey dataset whether their data are publicly available or whether researchers need specific permissions from NTPs before a copy of the dataset is provided. Towards the end of 2014, NTPs and survey coordinators will be invited to store their survey data (including anonymised individual-level data) according to a standard set of terms and conditions in this data repository.