Warning: This report is out-of-date. In particular, entire time-series of TB disease burden estimates are updated every year. For the latest data and analysis, please see the most recent edition of the global TB report.
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Abbreviations

ACSM  advocacy, communication and social mobilization
AFR   WHO African Region
AIDS  acquired immunodeficiency syndrome
AMR   WHO Region of the Americas
ARI   annual risk of infection
ART   antiretroviral therapy
CBC   community-based TB care
CFR   case fatality rate
CPT   co-trimoxazole preventive therapy
DOT   directly observed treatment
DOTS  the basic package that underpins the Stop TB Strategy
DRS   drug resistance surveillance or survey
DST   drug susceptibility testing
ECDC  European Centre for Disease Prevention and Control
EMR   WHO Eastern Mediterranean Region
EU    European Union
EUR   WHO European Region
FIND  Foundation for Innovative New Diagnostics
GDF   Global TB Drug Facility
GLC   Green Light Committee
GLI   Global Laboratory Initiative
Global Fund  The Global Fund to fight AIDS, Tuberculosis and Malaria
Global Plan  Global Plan to Stop TB, 2006–2015
GNI   gross national income
HBC   high-burden country of which there are 22 that account for approximately 80% of all new TB cases arising each year
HIV   human immunodeficiency virus
ICD-10 International Statistical Classification of Diseases
IPT   isoniazid preventive therapy
IRR   incidence rate ratio
ISTC  International Standards for Tuberculosis Care
MDG   Millennium Development Goal
MDR-TB multidrug-resistant tuberculosis (resistance to, at least, isoniazid and rifampicin)
NGO   nongovernmental organization
NTP   national tuberculosis control programme or equivalent
PAL   Practical Approach to Lung Health
PPM   Public–Private Mix
SEAR  WHO South-East Asia Region
TB    tuberculosis
UNAIDS Joint United Nations Programme on HIV/AIDS
UNITAID international facility for the purchase of diagnostics and drugs for diagnosis and treatment of HIV/AIDS, malaria and TB
USAID United States Agency for International Development
VR    vital registration
WHA   World Health Assembly
WHO   World Health Organization
WPR   WHO Western Pacific Region
XDR-TB TB caused by MDR strains that are also resistant to a fluoroquinolone and, at least, one second-line injectable agent (amikacin, kanamycin and/or capreomycin)
Acknowledgements

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The main report was written by Katherine Floyd and the Annex that explains methods used to produce estimates of disease burden was written by Philippe Glaziou. Karen Ciceri edited the report.

Philippe Glaziou analysed surveillance and epidemiological data and prepared the figures and tables on these topics, with assistance from Ana Bierrenbach, Tom Hiatt and Charalambos Sismanidis. Christian Gunneberg and Dennis Falzon analysed TB/HIV and MDR-TB data respectively, and prepared the figures and tables on these topics with support from Tom Hiatt. Mukund Uplekar contributed a summary of recent experience in implementing PPM. Christopher Fitzpatrick and Inés Garcia analysed financial data, and prepared the associated figures and tables.

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The main purpose of this report update is to provide the latest data on the TB epidemic and progress in control of the disease, based on data collected in the 2009 round of global TB data collection and previous years. Data are supplied primarily by national TB control programme managers and their staff. Those who used the online data collection system to report data to WHO in 2009 are listed below, and we thank them all for their invaluable contribution and collaboration.
Summary

This report is a short update to the WHO report on global tuberculosis (TB) control that was published in March 2009, based on data collected from July to September 2009. It is designed to fill an 18-month gap between the full reports of 2009 (in March) and 2010 (in October), following changes to the production cycle of the report in 2009 that have been made to ensure that future reports in the series contain more up-to-date data.

The report includes the latest (2008) estimates of the global burden of TB (incidence, prevalence and mortality). It also includes an assessment of progress in implementing the Stop TB Strategy and the Global Plan to Stop TB, which in combination have set out what needs to be done to achieve the 2015 global targets for TB control. These targets are that incidence should be falling by 2015 (MDG Target 6.c) and that prevalence and mortality rates should be halved by 2015 compared with their level in 1990. The latest data (up to 2010) on financing for TB control are presented, and progress towards the 2015 targets at global and regional level is analysed. The report also features updates about the work of the Global Laboratory Initiative and the WHO Global Task Force on TB Impact Measurement, and highlights achievements in TB control during the period 1995–2008 as well as the success of a new initiative in 2009 in which global TB data collection went online.

In 2008, there were an estimated 8.9–9.9 million incident cases of TB, 9.6–13.3 million prevalent cases of TB, 1.1–1.7 million deaths from TB among HIV-negative people and an additional 0.45–0.62 million TB deaths among HIV-positive people (classified as HIV deaths in the International Statistical Classification of Diseases), with best estimates of 9.4 million, 11.1 million, 1.3 million and 0.52 million, respectively. The number of notified cases of TB in 2008 was 5.7 million, equivalent to 55–67% of all incident cases, with a best estimate of 61% (10% less than the Global Plan milestone of a case detection rate of 71% in 2008). Among patients in the 2007 cohort, 86% were successfully treated; this is the first time that the target of 85% (first set in 1991) has been exceeded at global level. Progress in implementation of interventions to reduce the burden of TB in HIV-positive people has continued; in 2008, 22% of TB patients knew their HIV status (up from 20% in 2007) including 45% of patients in the African Region; 0.3 million people were enrolled on co-trimoxazole preventive therapy; and 0.1 million people were enrolled on antiretroviral therapy. Almost 30 000 cases of multidrug-resistant TB (MDR-TB) were notified in 2008; this is 11% of the total number of cases of MDR-TB estimated to exist among cases notified in 2008. Diagnosis and treatment of MDR-TB need to be rapidly expanded.

Funding for TB control has increased since 2002, and is expected to reach US$ 4.1 billion in 2010. Funding gaps remain, however; compared with the Global Plan, funding gaps amount to at least US$ 2.1 billion in 2010.

Globally, incidence rates peaked at 143 (range, 136–151) cases per 100 000 population in 2004. The world as a whole is on track to achieve MDG Target 6.c, as are eight of nine epidemiological subregions (the exception being African countries with a low prevalence of HIV). Six epidemiological subregions (Central Europe, Eastern Europe, the Eastern Mediterranean, high-income countries, Latin America and the Western Pacific) appear to have achieved the Stop TB Partnership target of halving the 1990 prevalence rate and four (Central Europe, high-income countries, Latin America and the Western Pacific) appear to have achieved the Stop TB Partnership target of halving the 1990 mortality rate, in advance of the target year of 2015. Prevalence and mortality rates are falling in all other regions with the exception of African countries with a low prevalence of HIV, although reaching the global target appears impossible in the African Region. Globally, the gulf between prevalence and mortality rates in 2008 and the target levels in African countries make it unlikely that 1990 prevalence and death rates will be halved by 2015 for the world as a whole.

Reductions in disease burden achieved to date follow fourteen years of intensive efforts at global, regional and country levels to implement the DOTS strategy (1995–2005) and its successor, the Stop TB Strategy (2006–). Between 1995 and 2008, a cumulative total of 36 million TB patients were successfully treated in DOTS programmes, and up to 6 million deaths were averted. To consolidate the major progress in global TB control achieved in recent years, intensified efforts to plan, finance and implement the range of interventions and approaches included in the Stop TB Strategy, according to the targets established in the Global Plan to Stop TB, are needed.

1 The 2009 report was the 13th annual report in a series that started in 1997.
The World Health Organization (WHO) has published an annual report on global tuberculosis (TB) control every year since 1997. The main purpose of the report is to provide a comprehensive and up-to-date assessment of the TB epidemic and progress in controlling the disease at global, regional and country levels in the context of global targets set for 2015. The 2009 report (the 13th in the series) was published, as in all previous years, on 24 March - World TB Day.

Despite its advantages, a major limitation of publishing the report on World TB Day is that much of the most important data are from two years prior to the year that the report is published. For example, with a production cycle of approximately nine months (from the date of the original request to countries for reporting of data to the date of publication, with data validation, review, analysis, writing, layout and printing in between), the 2009 report included case notifications as well as estimates of disease burden (incidence, prevalence and mortality) from 2007. The latest year for which most of the data on implementation of the Stop TB Strategy were available was also 2007.

To make the report more up-to-date, with an emphasis on data from the most recent complete calendar year, a decision to change the production cycle was taken by WHO in mid-2009. From 2010 onwards, annual reports will be published around October.

Publishing a report in October 2010 that includes data from 2009 requires two rounds of global TB data collection between the 2009 and 2010 reports. The 2009 round of data collection was conducted, as in previous years, from July to September. The next round of data collection (the 2010 round) will occur much earlier, around March/April 2010.

This short update to the 2009 WHO report on global TB control is designed to fill the 18-month gap between the major reports of March 2009 and October 2010. The main part of the report presents the latest data on the global TB epidemic and progress in TB control, up to and including data compiled in 2009. The following topics are covered (in the order in which they appear):

- Methods;
- The global burden of TB (incidence, prevalence and mortality) in 2008;
- Global targets for reducing the burden of TB, set for 2015;
- The WHO Stop TB Strategy and the Global Plan to Stop TB, which in combination set out what needs to be done to achieve the 2015 targets;

**BOX 1**

**What's new in this report?**

This report contains more up-to-date data than any report on global TB control previously published by WHO, with all of the key results based on data collected in 2009. The report is published only two months after completing the 2009 round of global TB data collection, in which data were reported by 198 countries and territories representing >99% of the world’s population and global TB cases.

Estimates of the burden of TB (incidence, prevalence and mortality) have been improved following 18 months of work by an expert group convened by the WHO Global Task Force on TB Impact Measurement as well as increased availability of data. The number of countries with direct measurements of HIV infection in TB patients has risen to 103 (up from 64 in the 2008 round of data collection), and TB mortality is now based on direct measurements from vital registration systems for 89 countries (compared with three for which such direct measurements were used in previous reports). Estimates have also been updated using in-depth analyses and country consultations conducted during a series of regional workshops and country missions in 2009. All estimates are provided with uncertainty intervals; this will become routine practice in all future reports. Estimates of the number of TB cases occurring among women are also included.

The report focuses on progress towards achieving the targets that have been set for 2015 within the context of the Millennium Development Goals and the Global Plan to Stop TB. Compared with previous reports, assessment of whether the target of a 70% case detection rate has been achieved is given much less attention. This reflects the fact that the target year (2005) has now passed, that there are difficulties in measuring this indicator, and increasing emphasis on achieving universal access to health care.

Besides reporting of data collected in 2009, the report also highlights achievements in TB control during the period 1995–2008, features updates about the work of the Global Laboratory Initiative and the WHO Global Task Force on TB Impact Measurement, and describes the success of a new initiative in 2009 in which global TB data collection went online.

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1 The exact timing will be defined after further consultations with those involved in reporting data.
• Progress in implementing the Stop TB Strategy and the Global Plan to Stop TB. Particular attention is given to analysis of case notifications, treatment outcomes, case detection rates, the role of public-private mix (PPM) initiatives in engaging all health-care providers in TB control, implementation of collaborative TB/HIV activities and the management of multi-drug resistant TB (MDR-TB) and extensively drug-resistant TB (XDR-TB);
• Financing for TB control;
• Progress towards the 2015 targets for reducing the burden of TB. This section provides an up-to-date assessment of progress towards achieving the targets for reductions in incidence, prevalence and mortality;
• Improving measurement of the burden of TB. This section summarizes the current status of the work of the WHO Global Task Force on TB Impact Measurement;
• Conclusions.

The report update also contains an annex that explains the methods used to produce estimates of disease burden. This annex has been included following important updates to the methods used to produce such estimates in 2009 (BOX 1).

1. Methods

For the 2009 round of data collection, data collection forms were updated from those used in 2008. Efforts were made to shorten the forms and to simplify the data being requested wherever possible. Two versions of the data collection form were developed (a long form and a short form). The short form was adapted for use in high-income countries (that is, countries with a gross national income per capita ≥US$ 11 906 in 2008, as defined by the World Bank) and/or low-incidence countries (defined as countries with an incidence rate <20 cases per 100 000 population or <10 cases in total). In consultation with WHO regional offices, some countries that met the criteria for receiving the short form were instead requested to complete the long form. This included countries that had in previous years provided the more detailed financial data requested on the long form, and island states in the Western Pacific Region.

Both forms requested data on the following topics: case notifications and treatment outcomes, including breakdowns by age, sex and HIV status; an overview of services for the diagnosis and treatment of TB; laboratory diagnostic services; human resource development; drug management; monitoring and evaluation, including impact measurement; collaborative TB/HIV activities; management of drug-resistant TB; TB control in vulnerable populations and high-risk groups; health systems strengthening and the integration of TB control in primary health care; TB infection control; the Practical Approach to Lung Health (PAL); PPM; advocacy, communication and social mobilization (ACSM); operational research; adoption and use of new technologies; the budgets of national TB control programmes (NTPs) in 2008 and 2009; utilization of general health services (hospitalization and outpatient visits) during treatment; and NTP expenditures in 2008.

For the first time in 2009, a web-based online system (http://www.stopbt.org/tme) was used to report and validate data in all regions except the European Region (BOX 2). This new system was developed in mid-2009 and, despite initial concerns about how many countries would be willing to report data in this new way, proved to be a great success. Feedback was universally positive, and 198 countries and territories (out of a total of 204 from which data were requested) representing >99% of the world’s population and global TB cases reported data online. This included all countries in the African Region (46/46), the Eastern Mediterranean Region (22/22), the South-East Asia Region (11/11) and the Region of the Americas (36/36). The only missing reports were from Niue, Palau and Wallis and Futuna Islands (in the Western Pacific Region) and Austria, Monaco and San Marino (in the European Region). Following the deadline for reporting of data, all reports were carefully reviewed using a system of in-built validation checks (also available to country-based staff reporting data), with any follow-up queries returned to respondents online.

All data collected online in 2009 were imported to a master database that holds the TB-related data that have been compiled by WHO since 1995. Data from the two online systems used in the European Region1 were uploaded to the master database separately. For the purposes of this report, all data in the global and European online systems as of 10 November 2009 were imported to the master database and used, together with historical data reported in previous years, to produce analyses and related tables and figures. Country respondents continue to have the option of updating or adding data to the online system, which will be used for analyses conducted for the 2010 report.

Three additional points should be highlighted:
• NTPs sometimes provide WHO with updated information for previous years, for incorporation in the global TB database. As a result, the data presented in this report may differ from those published in previous reports;
• Assessment of progress in implementing PPM initiatives and global efforts to strengthen laboratory services and

1 The European Region already has its own system for online reporting of data.
2 One system for countries of the European Union, managed by the European Centre for Disease Control and Prevention (ECDC); the other for all European countries, managed by the WHO Regional Office for the European Region.
impact measurement, both of which are featured in this report, draw on information from key informants as well as the WHO TB data collection form; the annual data collection form and database system used by WHO are designed for collecting aggregated national data. They are not recommended for collection of data within countries.1

The new system has the following advantages:

- It provides a secure and easy approach for reporting of data;
- Data are automatically saved and stored in the global TB database, which also contains data collected in previous years;
- The task of reporting data can be shared among various colleagues;
- There is no need to complete the report at one time; users can log on and edit parts of the report as often as necessary before the deadline for reporting of data;
- Data are checked as they are being entered (real-time validation);
- Users have access to a report that highlights any inconsistencies among different sections of a report and any inconsistencies with data provided in previous years;
- Data entry screens are tailored for use by each country, and are available in English, French and Spanish;
- Users have access to summary tables showing real-time progress in reporting at regional and country levels;
- All changes are logged to ensure documentation of changes to data;
- There is no need to submit a paper form or an Excel spreadsheet.

Passwords were issued to NTP representatives as well as to WHO staff at global, regional and country levels. All those using the system were able to assess progress in completing reports and had a common platform for reviewing data and resolving queries.

The system was a great success: 198 reports were submitted online, and feedback from users was universally positive. In 2010, the system will be further developed, for example to allow easy downloading of data and the generation of country profiles.

### 2. The global burden of TB

#### 2.1 Incidence

In 2008, there were an estimated 9.4 (range, 8.9–9.9 million) million incident cases (equivalent to 139 cases per 100 000 population) of TB globally (TABLE 1, FIGURE 1). This is an increase from the 9.3 million TB cases estimated to have occurred in 2007, as slow reductions in incidence rates per capita continue to be outweighed by increases in population. Estimates of the number of cases broken down by age and sex are being prepared by an expert group as part of an update to the Global Burden of Disease study,4 due to be published in 2010. Provisional analyses indicate that women account for an estimated 3.6 million cases (range, 3.4–3.8 million).

Most of the estimated number of cases in 2008 occurred in Asia (55%) and Africa (30%),5 with small proportions of cases in the Eastern Mediterranean Region (7%), the European Region (5%) and the Region of the Americas (3%). The 22 high-burden countries (HBCs, defined as the countries that rank first to 22nd in terms of absolute numbers of cases and which have received particular attention at the global level since 2000) shown in TABLE 1 account for 80% of all estimated cases worldwide. The five countries that rank first to fifth in terms of total numbers of incident cases in 2008 are India (1.6–2.4 million), China (1.0–1.6 million), South Africa (0.38–0.57 million), Nigeria (0.37–0.55 million) and Indonesia (0.34–0.52 million). India and China alone account for an estimated 35% of TB cases worldwide.

1 WHO recommendations for recording and reporting within countries are described at: [http://www.who.int/tb/dots/r_and_r_forms/en/index.html](http://www.who.int/tb/dots/r_and_r_forms/en/index.html)


3 This expert group is convened by the WHO Global Task Force on TB Impact Measurement. See also section 8 of this report.


5 Asia here means the WHO regions of South-East Asia and the Western Pacific. Africa means the WHO African Region.
Of the 9.4 million incident cases in 2008, an estimated 1.2–1.6 million (13–16%) were HIV-positive, with a best estimate of 1.4 million (15%) (TABLE 1, FIGURE 2). Of these HIV-positive cases, 78% were in the African Region and 13% were in the South-East Asia Region.

### 2.2 Prevalence

There were an estimated 11.1 million (range, 9.6–13.3 million) prevalent cases of TB in 2008 (TABLE 1), equivalent to 164 cases per 100 000 population.

### 2.3 Mortality

In 2008, an estimated 1.3 million (range, 1.1–1.7 million) deaths, including 0.5 million (range, 0.45–0.62 million) deaths among women, occurred among HIV-negative incident cases of TB. This is equivalent to 20 deaths per 100 000 population (TABLE 1). There were an estimated 0.5 million deaths among incident TB cases who were HIV-positive (data not shown); these deaths are classified as HIV deaths in the 10th revision of the International Statistical Classification of Diseases (ICD-10). The number of TB deaths per 100 000 population among HIV-negative people plus the estimated TB deaths among HIV-positive people equates to a best estimate of 28 deaths per 100 000 population.

### 2.4 MDR-TB and XDR-TB

There were an estimated 0.5 million cases of MDR-TB in 2007.2 There were 27 countries (15 in the European Region)

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1. Mortality excluding HIV, according to ICD-10.
2. Percentage of incident TB cases that are HIV-positive.
3. Estimates are provisional, pending further analyses and data collection in 2010.
4. Indicates data not available.

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Table 1: Estimated epidemiological burden of TB, 2008

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<th>Region</th>
<th>Population</th>
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<tr>
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<td>170 014 547</td>
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</tr>
</tbody>
</table>

1 This figure is considerably lower than the estimate previously published for 2007. This reflects changes to methods used to estimate the number of prevalent cases of TB – see ANNEX.
FIGURE 1
Estimated TB incidence rates, 2008

FIGURE 2
Estimated HIV prevalence in new TB cases, 2008
that account for 85% of all such cases; these countries have been termed the 27 high MDR-TB burden countries (see also SECTION 5.5). The countries that ranked first to fifth in terms of total numbers of MDR-TB cases in 2007 were India (131 000), China (112 000), the Russian Federation (43 000), South Africa (16 000) and Bangladesh (15 000). By November 2009, 57 countries and territories had reported at least one case of XDR-TB.

3. Global targets for reductions in disease burden

Global targets for reducing the burden of disease attributed to TB are summarized in TABLE 2. Achieving the targets set for 2015 is the main focus of national and international efforts in TB control. These targets are (i) to halt and reverse the incidence of TB by 2015 (MDG Target 6.c) and (ii) to halve TB prevalence and death rates by 2015, compared with their levels in 1990.

![TABLE 2](https://example.com/table2.png)

**HEALTH IN THE MILLENNIUM DEVELOPMENT GOALS SET FOR 2015**

**Goal 6: Combat HIV/AIDS, malaria and other diseases**

**Target 6.c:** Halt and begin to reverse the incidence of malaria and other major diseases

**Indicator 6.9:** Incidence, prevalence and death rates associated with TB

**Indicator 6.10:** Proportion of TB cases detected and cured under DOTS

**Stop TB Partnership targets set for 2015 and 2050**

**By 2015:** The global burden of TB (per capita prevalence and death rates) will be reduced by 50% relative to 1990 levels.

**By 2050:** The global incidence of active TB will be less than 1 case per million population per year.

4. The Stop TB Strategy and the Global Plan to Stop TB

The Stop TB Strategy¹ is the approach recommended by WHO to reduce the burden of TB in line with global targets set for 2015. The strategy is summarized in TABLE 3. The six major components of the strategy are: (i) pursue high-quality DOTS expansion and enhancement; (ii) address TB/HIV, MDR-TB, and the needs of poor and vulnerable populations; (iii) contribute to health system strengthening based on primary health care; (iv) engage all care providers; (v) empower people with TB, and communities through partnership; and (vi) enable and promote research.

The Stop TB Partnership’s Global Plan to Stop TB, 2006–2015 (hereafter the Global Plan) sets out the scale at which the interventions included in the Stop TB Strategy need to be implemented to achieve the 2015 targets.² The major targets (which can be defined as input, output and outcome targets) in the Global Plan include:

- Detection of 84% of infectious cases globally by 2015;
- A treatment success rate among smear-positive cases of 87% by 2015;
- HIV testing of 85% of TB patients by 2010, with this level sustained in subsequent years;
- Enrolment of 95% of HIV-positive TB patients on co-trimoxazole preventive therapy (CPT) by 2010, with this level sustained in subsequent years;
- Enrolment of 320 000 HIV-positive TB patients on antiretroviral treatment (ART) by 2010, equivalent to 80% of the TB patients estimated to be in need of such treatment at the time the Global Plan was developed;
- Diagnosis and treatment of 80% of the estimated number of smear-positive and/or culture-positive cases of MDR-TB by 2015, in programmes following international guidelines for the management of drug-resistant TB. The number of


patients to be treated in 2015 has been estimated by the MDR-TB working group of the Stop TB Partnership as around 357,000 cases in the 27 high MDR-TB burden countries;

- Mobilization of between US$ 3 billion and US$ 9 billion per year, increasing over time, to finance implementation of the Stop TB Strategy, plus at least US$ 1 billion per year for research and development related to new drugs, new diagnostics and new vaccines.

The next section presents the latest data on progress made in implementing the Stop TB Strategy, where appropriate in the context of targets set in the Global Plan.
**Achievements in TB control, 1995–2008**

WHO developed the DOTS strategy as the internationally recommended approach to TB control in the mid-1990s. DOTS is also the foundation of the Stop TB Strategy, which was launched by WHO in 2006 to guide TB control efforts during the period 2006–2015. The start of WHO efforts to systematically monitor progress in TB control on an annual basis in 1995 coincided with global promotion and expansion of the DOTS strategy.

The data that have been compiled 1995–2009 allow an assessment of the achievements of TB control between 1995 and 2008. During this period, 36 million patients have been successfully treated in DOTS programmes. This has averted millions of deaths – at least 2 million but possibly as many as 6 million, compared with what would have occurred had DOTS not been implemented.  

Globally, incidence rates appear to have peaked, at 143 (range, 136–151) cases per 100,000 population in 2004. This means that the world is on track to achieve MDG Target 6.c, as are eight of nine epidemiological subregions (the exception being African countries with a low prevalence of HIV). Six epidemiological subregions (Central Europe, Eastern Europe, the Eastern Mediterranean, high-income countries, Latin America and the Western Pacific) appear to have achieved the Stop TB Partnership target of halving the 1990 prevalence rate and four (Central Europe, high-income countries, Latin America and the Western Pacific) appear to have achieved the Stop TB Partnership target of halving the 1990 mortality rate, in advance of the target year of 2015. Prevalence rates are also falling globally and in all other regions with the exception of African countries with a low prevalence of HIV.  

1 Excluding deaths averted among HIV-positive people, which are classified as HIV rather than TB deaths.  

2 Defined as a case notification rate maintained at the 1995 level.

### 5. Progress in implementing the Stop TB Strategy and the Global Plan to Stop TB

#### 5.1 Case notifications

In 2008, 5.7 million cases of TB (new cases and relapse cases) were notified to NTPs, including 2.7 million new smear-positive cases, 2.0 million new smear-negative pulmonary cases (or cases for which smear status was unknown) and 0.8 million new cases of extrapulmonary TB (TABLE 4).  

Among pulmonary cases, 57% of total notifications were smear-positive. Among the 22 HBCs, the percentage of notifications that were smear-positive was much lower in the Russian Federation (31%), Zimbabwe (33%), Kenya (44%) and Ethiopia (45%), while a comparatively high proportion were smear-positive in the Democratic Republic of the Congo (86%), Bangladesh (83%), Viet Nam (74%) and Cambodia (72%).

#### 5.2 Treatment outcomes

Globally, the rate of treatment success for new smear-positive cases treated in the 2007 cohort was 86% (TABLE 5). This is the first time that the treatment success rate has exceeded the global target of 85%, which was set by the World Health Assembly (WHA) in 1991. Three regions – the Eastern Mediterranean (88%), Western Pacific (92%), and South-East Asia (88%) regions – exceeded the target, as did 53 countries. The treatment success rate was 79% in the African Region, 82% in the Region of the Americas and 67% in the European Region (where death and failure rates are comparatively high). Between 2006 and 2007, treatment success rates were maintained or improved in all regions with the exception of the European Region.  

Among the 22 HBCs, the 85% target was met or exceeded in 13 countries, including in Afghanistan for the first time. Encouragingly, the rate of treatment success was also 85% in Kenya and 88% in the United Republic of Tanzania, showing that countries in which there is a high prevalence of HIV among TB cases are able to achieve this target.

#### 5.3 Case detection rates and the role of PPM in engaging all care providers

The case detection rate (calculated as the number of notified cases of TB in one year divided by the number of estimated incident cases of TB in the same year, and expressed as a percentage) has been a much-used indicator of progress in TB control for more than a decade. The considerable attention given to the case detection rate was in line with the two principal global targets (case detection and treatment success rates) set for TB control during the period 1991 to 2005. The targets of reaching a 70% case detection rate and an 85% treatment success rate by 2000 were set in 1991 by the WHA, with the target year subsequently reset to 2005.  

This report update, as well as future reports on global TB control, will gradually place less emphasis on the case detection rate. There are several good reasons for doing this:

- The target year of 2005 has now passed;
The Global Plan established targets well in excess of 70% for most of the period 2006–2015; there is increasing emphasis on achieving universal access to health care, which implies detecting and treating well in excess of 70% of cases; the difficulties with estimating incidence in absolute terms – the value required for the denominator in the calculation of the case detection rate (see ANNEX for further details on estimating the incidence of TB); and
there has been a major shift towards focusing on impact targets i.e. the 2015 targets for reducing the burden of disease (TABLE 2).

The best estimate of the case detection rate of new smear-positive cases in 2008 was 62% (range 56–68%) (TABLE 6), which is 9% less than the milestone of 71% that was set in the Global Plan. The highest rates of case detection in 2008 are estimated to be in the European Region and the Region of the Americas, followed by the Western Pacific Region, with the lowest rate estimated for the African Region. Among the HBCs, the highest rates of case detection in 2008 are estimated to be in Indonesia, Brazil, China, the Russian Federation and the United Republic of Tanzania, with the lowest rate (24%, range 20–30%) in Zimbabwe. Of note is the case detection rate estimated for Viet Nam, which at 62% (range, 45–75%) is considerably lower than estimates published in previous years, following new evidence from a nationwide survey of the prevalence of TB disease completed in 2007 combined with an in-depth analysis of surveillance data in early 2009.

The case detection rate for all forms of TB (TABLE 7) is estimated at 61% in 2008 (range 55–67%). Among regions, the European and Western Pacific regions and the Region of the Americas have the highest rates of case detection; the African Region has the lowest. There is considerable variation among HBCs, although, as for detection of smear-
positive cases, the highest estimated rates of case detection in 2008 were in Brazil, China and the Russian Federation as well as India, Indonesia, Kenya and South Africa.

Despite difficulties with estimating the case detection rate, efforts to increase the percentage of TB cases that are diagnosed and treated according to international guidelines is clearly of major importance. In many countries, one of the best ways to do this is for NTPs to establish collaboration with the full range of health-care providers through PPM initiatives.\(^1\)

PPM initiatives are being scaled up in many countries but, as in previous rounds of global TB data collection, the contribution of different care providers to case notifications is hard to quantify. In 2008, only a handful of HBCs reported data on the source of referral or place of treatment of TB patients. This reflects the fact that most NTPs are not yet recording data on the source of referral and the place of treatment of TB patients on a routine basis.\(^2\) In the absence of such data, BOX 4 provides examples of what can be achieved through PPM, using data from Bangladesh, Kenya and the Philippines.

Overall, rates of case detection have stagnated since 2006, and renewed efforts to increase case-finding are needed to keep pace with Global Plan milestones (**FIGURE 3**). The gap between estimated case detection rates in practice and the milestones included in the Global Plan is biggest in the African Region. A gap is opening up in the Western Pacific Region, where case detection rates have remained stable since 2005. The case detection rate has been increasing in the Eastern Mediterranean and South-East Asia regions, and this rate of progress needs to be maintained to keep pace

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2. WHO recommends that the source of referral and the place of treatment should be routinely recorded and reported.
with the Global Plan. The European Region is the only region where current estimates of the case detection rate exceed Global Plan milestones.

### 5.4 Collaborative TB/HIV activities

Collaborative TB/HIV activities are essential to ensure that HIV-positive TB patients are identified and treated appropriately, and to prevent TB in HIV-positive people. These activities include establishing mechanisms for collaboration between TB and HIV programmes; infection control in healthcare and congregate settings; HIV testing of TB patients and – for those TB patients infected with HIV – CPT and ART; and intensified TB case-finding among people living with HIV followed by isoniazid preventive therapy (IPT) for those without active TB. HIV testing of TB patients, provision of CPT and referral for ART are typically the responsibility of NTPs, while national HIV programmes are typically responsible for intensified case-finding among HIV-positive people and provision of IPT to those without active TB.

Further progress in implementation of collaborative TB/HIV activities was made in 2008, consolidating achievements documented in previous reports. Almost 1.4 million TB patients knew their HIV status in 2008 (22% of notified cases), up from 1.2 million in 2007 (FIGURE 4). The highest rates of HIV testing were reported in the European Region, the Region of the Americas and the African Region, where 79%, 49% and 45% of TB patients knew their HIV status, respectively (TABLE 8). There were 50 countries in which at least 75% of TB patients knew their HIV status, including 11 African countries (FIGURE 5). Of the TB patients who were known to be HIV-positive, around two-thirds or just over 0.2 million were enrolled on CPT and around one-third or 0.1 million were enrolled on ART (FIGURE 6); these numbers are about one-third of the milestones of 0.6 million and 0.3 mil-

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**TABLE 6**

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- Estimates for all years are recalculated as new information becomes available and techniques are refined, so they may differ from those published previously.
- Estimates are provisional, pending further analyses and data collection in 2010.
- Indicates data not available.

Although the numbers remain a small fraction of the number of people who know that they are HIV-positive and a smaller fraction still of the estimated total number of HIV-positive people worldwide, screening for TB among HIV-positive people and provision of IPT to those without active TB more than doubled between 2007 and 2008. The number of HIV-positive people screened for TB increased from 0.6 million to 1.4 million, and the number of people who were provided with IPT grew from under 30 000 in 2007 to around 50 000 in 2008 (FIGURE 7).

### 5.5 MDR-TB and XDR-TB

Globally, just under 30 000 cases of MDR-TB were notified to WHO in 2008, mostly by European countries and South Africa (FIGURE 8, TABLE 9). This was 1.1% of the estimated number of cases of MDR-TB among all notified cases of pulmonary TB in 2008 (TABLE 9). The number of notified cases reported to WHO was slightly lower than in 2007, but country reports suggest that numbers will be higher in 2009 and 2010, including in the three countries where the estimated number of cases is highest: China, India and the Russian Federation (FIGURE 8, TABLE 9).

Among notified cases, an increasing share is being enrolled on treatment in projects or programmes approved by the Green Light Committee (GLC), and are thus known to be receiving treatment according to international guidelines. The number reached around 6 000 in 2008, and is expected to rise to almost 29 000 in 2010. This remains a small fraction of the estimated number of cases, and much more rapid expansion of diagnosis and treatment – within and outside projects and programmes approved by the GLC – is needed to approach the targets included in the MDR-TB component of the Global Plan (FIGURE 9).

National data on treatment outcomes among cohorts of at least 100 patients are currently limited to six countries: Brazil, Kazakhstan, Latvia, Peru, Romania and Turkey (FIGURE 10). Rates of treatment success are variable, rang-
**FIGURE 3**
Case detection rates 1995–2008 (grey) compared with Global Plan targets/milestones (red), globally and in seven sub-regions

**TABLE 8**
HIV testing and treatment in TB patients, by WHO region, 2008

<table>
<thead>
<tr>
<th>Region</th>
<th>Number of TB patients with known HIV status (thousands)</th>
<th>% of notified TB patients tested for HIV</th>
<th>% of tested TB patients HIV-positive</th>
<th>% of estimated HIV-positive TB cases* identified by CPT</th>
<th>% of identified HIV-positive TB patients started on CPT</th>
<th>% of identified HIV-positive TB patients started on ART</th>
<th>Regional distribution of estimated HIV-positive TB cases (%)</th>
<th>Number of HIV-positive people screened for TB (thousands)</th>
<th>Number of HIV-positive people provided IPT (thousands)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFR</td>
<td>636</td>
<td>45</td>
<td>46</td>
<td>27</td>
<td>73</td>
<td>30</td>
<td>78</td>
<td>729</td>
<td>26</td>
</tr>
<tr>
<td>AMR</td>
<td>113</td>
<td>49</td>
<td>15</td>
<td>45</td>
<td>36</td>
<td>67</td>
<td>2.7</td>
<td>48</td>
<td>12</td>
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<tr>
<td>EMR</td>
<td>22</td>
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<td>4.1</td>
<td>5.8</td>
<td>39</td>
<td>55</td>
<td>1.1</td>
<td>12</td>
<td>0.7</td>
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<td>EUR</td>
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<td>48</td>
<td>61</td>
<td>29</td>
<td>1.7</td>
<td>205</td>
<td>9.2</td>
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<td>SEA</td>
<td>94</td>
<td>4.1</td>
<td>18</td>
<td>9.3</td>
<td>54</td>
<td>35</td>
<td>13</td>
<td>300</td>
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<td>WPR</td>
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<td>28</td>
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<td>Global</td>
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<td>26</td>
<td>25</td>
<td>71</td>
<td>32</td>
<td>100</td>
<td>1384</td>
<td>48</td>
</tr>
</tbody>
</table>

*Includes estimated HIV-positive TB cases in countries which did not provide information on testing.
ing from below 40% to above 80%, with lower cure rates and higher death rates among retreatment cases.

One of the most important constraints to rapid expansion of diagnosis and treatment for MDR-TB is laboratory capacity. Without greater capacity to diagnose MDR-TB, the number of cases diagnosed and treated will continue to remain low. In 2008, diagnostic testing for drug susceptibility, or DST, among new cases diagnosed and treated will continue to remain low. In 2008, diagnostic testing for drug susceptibility, or DST, among new cases of TB was almost entirely confined to the European Region and the Region of the Americas (FIGURE 11). Among retreatment cases, DST was done for 17% of cases in the Region of the Americas and for 13% in the European Region, with figures of less than 10% in all other regions.

Recent efforts to strengthen laboratory services, under the umbrella of the Global Laboratory Initiative, are highlighted in BOX 5.

FIGURE 4
HIV testing for TB patients, 2003–2008. Number (bars) and percentage (line) of notified new and re-treatment TB cases for which the HIV status (HIV-positive in grey) of the patient was recorded in the TB register. The numbers under each bar show the number of countries reporting data, followed by the percentage of total estimated HIV-positive TB cases accounted for by reporting countries.
**FIGURE 5**
HIV testing for TB patients, 2008

**FIGURE 6**
Co-trimoxazole preventive therapy and antiretroviral therapy for HIV-positive TB patients, 2003–2008. Numbers (bars) and percentages (above bars) of estimated HIV-positive people started on CPT (red) and ART (grey). The numbers under each bar show the number of countries reporting data, followed by the percentage of total estimated HIV-positive TB cases accounted for by reporting countries.
FIGURE 7
Intensified TB case-finding and IPT provision among HIV-positive people. Numbers (bars) and percentages (above bars) of estimated HIV-positive people screened for TB (red) and started on IPT (grey). Numbers under bars show the number of countries reporting data followed by the percentage of total estimated HIV-positive people accounted for by reporting countries.

* Percentages for IPT figures are calculated using the estimated number of HIV-positive people without active TB.

FIGURE 8
Notified cases of MDR-TB (2005–2008) and projected numbers of patients to be enrolled on treatment (2009–2010). The numbers under each bar show the number of countries reporting data.

FIGURE 9
Notified cases of MDR-TB (2007–2008) and projected numbers of patients to be enrolled on treatment (2009–2010) in the 27 high MDR-TB burden countries (grey) compared with targets/milestones included in the Global Plan (red). Numbers are for smear and/or culture-positive cases of MDR-TB.

* The targets/milestones for scaling-up treatment of MDR-TB in the Global Plan are based on updated projections produced in March 2009, in preparation for a ministerial meeting on MDR/XDR-TB held in Beijing, China in April 2009.

FIGURE 10
Treatment outcomes for patients with MDR-TB in six countries, 2006 cohort. The total number of patients in each cohort is shown under each bar. Only countries reporting outcomes for >100 MDR-TB cases and for both new and retreatment patients shown. Countries ranked by proportion cured among new cases.

* Data from 2005.
### TABLE 9
Number of cases of MDR-TB estimated, notified and expected to be treated, 27 high MDR-TB burden countries and WHO regions

<table>
<thead>
<tr>
<th>Country</th>
<th>Estimated % of all TB cases with MDR-TB</th>
<th>Total number of estimated cases of MDR-TB in 2007a</th>
<th>Estimated cases of MDR-TB among notified cases of pulmonary TBb (A)</th>
<th>Notified cases of MDR-TB (B)</th>
<th>Notified cases of MDR-TB as % of estimated cases of MDR-TB among all notified cases of pulmonary TB (B/A)c</th>
<th>Expected number of cases of MDR-TB to be treated</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armenia</td>
<td>17</td>
<td>486</td>
<td>284</td>
<td>128</td>
<td>45</td>
<td>60 120</td>
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<td>Azerbaijan</td>
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<td>3 916</td>
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<td>147</td>
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<td>Belarus</td>
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<td>120 -</td>
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<td>3 983</td>
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<td>13</td>
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<td>929</td>
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<td>864 1 494</td>
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<td>1 399</td>
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<td>560 540</td>
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<td>6 960</td>
<td>17</td>
<td>8 383 12 000</td>
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<tr>
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<td>8 506</td>
<td>6 219</td>
<td>73</td>
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<td>- -</td>
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<td>720 1 010</td>
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</tr>
<tr>
<td>Viet Nam</td>
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<td>2 877</td>
<td>-</td>
<td>-</td>
<td>- - 350</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>High MDR-TB burden countries</strong></td>
<td><strong>5.7</strong></td>
<td><strong>435 470</strong></td>
<td><strong>242 938</strong></td>
<td><strong>22 577</strong></td>
<td><strong>9.3</strong></td>
<td><strong>25 770</strong></td>
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<td>7 736</td>
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<td>8 364 10 587</td>
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<tr>
<td>AMR</td>
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<td>2 209</td>
<td>39</td>
<td>3 546 3 198</td>
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<td>702 1 060</td>
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<tr>
<td>WPR</td>
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<td>135 411</td>
<td>76 835</td>
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<td>2 326 5 627</td>
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<tr>
<td><strong>Global</strong></td>
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<td><strong>510 545</strong></td>
<td><strong>266 768</strong></td>
<td><strong>28 753</strong></td>
<td><strong>11</strong></td>
<td><strong>36 508 54 841</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


* Total numbers of notified cases of pulmonary TB are multiplied by 0.9 to estimate the number of cases that would be culture-positive if tested.

* Percentages may exceed 100% as a result of conservative estimates of MDR-TB and/or notification of cases of MDR-TB from a previous year.

* Indicates data not available.
**FIGURE 11**

Diagnostic DST for new and re-treatment cases, by WHO region, 2008. The numbers under each bar show the number of countries reporting data, followed by the percentage of cases of MDR-TB reported worldwide accounted for by countries in each region.

**DATA**

- AFR (13, 3%)
- AMR (20, 4%)
- EMR (13, 1%)
- EUR (38, 92%)
- SEAR (4, 0%)
- WPR (12, 1%)
- Global (100)

- AFR (23, 9%)
- AMR (23, 13%)
- EMR (13, 3%)
- EUR (37, 60%)
- SEAR (4, 7%)
- WPR (11, 8%)
- Global (111)

*Data from India excluded as <0.1% of notified cases were tested.*

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**BOX 5**

EXPAND-TB: Expanding Access to New Diagnostics for patients at risk of multidrug resistant tuberculosis (MDR-TB)

To address the massive need to scale up laboratory services with the capability to test for drug-resistant TB, a network of international partners has combined to form the Global Laboratory Initiative (GLI). The GLI is working with NTPs, non-governmental organizations, technical and financial partners, and WHO offices at country and regional levels to strengthen laboratory services and to encourage the adoption of new diagnostic tools once these have been endorsed by WHO. The secretariat of the GLI is hosted by the Stop TB Department of WHO.

In 2008, UNITAID approved a project called EXPAND-TB, which will support the procurement and use of new TB diagnostic tools in low and lower-middle income countries between 2009 and 2013. Project partners include WHO-GLI, the Foundation for Innovative New Diagnostics (FIND) and the Stop TB Partnership’s Global Drug Facility (GDF). EXPAND-TB aims to narrow the diagnostic gap affecting control of MDR-TB by accelerating access to new diagnostic technologies within appropriate laboratory services, accompanied by the necessary transfer of technology while also ensuring that new tools are properly integrated within TB control programmes.

EXPAND-TB requires extensive complementary resources to strengthen laboratory infrastructure and services in recipient countries. Building on the foundation of UNITAID support, the project is seeking to mobilize resources from other partners to support the upgrading and modernization of national TB reference laboratories, training in good laboratory practice, bio-safety, new diagnostic methods, and technical assistance.

EXPAND-TB currently covers 27 countries (see map).
6. Financing for TB control

6.1 High-burden countries

The funding available for TB control in the 22 HBCs has increased each year since 2002, and is expected to reach US$ 2.6 billion in 2010 (FIGURE 12, FIGURE 13, FIGURE 14). Most of this funding has been used to support DOTS implementation, although the share for MDR-TB (mostly accounted for by funding in the Russian Federation and South Africa) has increased since 2007 (FIGURE 12). The relatively small amount of funding reported for collaborative TB/HIV activities reflects the fact that funding for most of these interventions is channelled through national HIV programmes and nongovernmental organizations (NGOs) rather than via NTPs. National governments are the largest source of funding (FIGURE 13): for example, they account for 84% of total expected funding in 2010. Financing from the Global Fund has become increasingly important since 2004, reaching just over US$ 200 million in 2010. Other donor funding is expected to amount to just under US$ 100 million in 2010. In absolute terms, 68% of the funding expected in 2010 is accounted for by just two countries: the Russian Federation and South Africa (FIGURE 14).1

Although increases in funding have continued in 2009 and 2010 despite a global financial crisis, NTPs continue to report funding gaps (FIGURE 15). The funding gaps reported since 2007 have been much larger than those reported during 2002–2006, as NTPs expand the range of interventions being planned in line with the Stop TB Strategy. Funding gaps are not only for interventions such as treatment of MDR-TB and collaborative TB/HIV activities, however; some countries continue to report funding gaps for first-line anti-TB drugs as well. The funding gap reported for 2010 is US$ 0.5 billion.

Trends in funding for the 22 HBCs as a whole conceal important variations among countries (TABLE 10, FIGURE 16, FIGURE 17). Both NTP budgets and funding of NTPs have been increasing in most countries; however, there are exceptions where funding has fluctuated markedly, both up and down (for example in Bangladesh, Myanmar, Viet Nam, and Zimbabwe) and where funding is expected to be lower in 2010 compared with 2009 (for example in Brazil and Pakistan) (FIGURE 16). Funding has been closest to keeping pace with increases in NTP budgets in Brazil, China, India, the Philippines and the Russian Federation; in contrast, funding gaps have persisted in most African countries as well as Afghanistan, Myanmar and Pakistan. In 2010, the Russian Federation, Thailand, Brazil and China will rely primarily on domestic funding (including loans),2 but in other HBCs around 40% or more of available funding is from grants from external donors. Afghanistan and the Democratic Republic of the Congo are particularly dependent on donor funding.

There is also considerable variation in the cost per patient treated under DOTS (FIGURE 18). This ranges from under US$ 100 (in Bangladesh, India, Myanmar and Pakistan) to around US$ 1000 (in Brazil and South Africa) to over US$ 5000 (in the Russian Federation; the main outlier). These differences are partly linked to income levels (for example, Brazil and South Africa are upper-middle income countries where prices for inputs such as NTP staff and hospital care are higher than in low-income countries), but are also linked to the extent to which hospitalization is relied upon during treatment. This is the major reason for particularly high costs in the Russian Federation, where an extensive network of TB hospitals and sanatoria is used to treat TB patients. Costs in African countries also tend to be higher than those in Asian countries, even among countries with similar income levels.

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1 Financial data were not reported for South Africa in 2009. Data and estimates for South Africa in this section are based on adjustments to data reported in 2006 and 2007.
2 The same is likely to be true for South Africa, based on data reported in previous years, but financial data were not reported to WHO in 2009 pending completion of a costing study commissioned by the Department of Health.
**Figure 14**
Funding for TB control by country, high-burden countries, 2002–2010

**Figure 15**
Funding gaps reported by NTPs, high-burden countries, 2002–2010

**Figure 16**
NTP budgets and available funding, 22 high-burden countries, 2002–2010
**TABLE 10**

NTP budgets, available funding, cost of utilization of general health-care services and total TB control costs, high-burden countries, 2010 (US$ millions)

<table>
<thead>
<tr>
<th>Country</th>
<th>NTP Budget</th>
<th>Government (excluding loans)</th>
<th>Loans</th>
<th>Grants (excluding Global Fund)</th>
<th>Global Fund</th>
<th>Funding Gap</th>
<th>Cost of Utilization of General Health-Care Services</th>
<th>Total TB Control Costs</th>
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</thead>
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<td>1.1</td>
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<td>0.1</td>
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<td>39</td>
<td>19</td>
<td>29</td>
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<td>22</td>
<td>22</td>
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<td>1.0</td>
<td>5.8</td>
<td>4.3</td>
<td>20</td>
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<td>3.5</td>
<td>19</td>
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<td>0</td>
<td>12</td>
<td>2.0</td>
<td>18</td>
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<tr>
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<td>33</td>
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<tr>
<td>South Africab</td>
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<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
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<td>9.5</td>
<td>0.6</td>
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<tr>
<td>Viet Nam</td>
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<td>0</td>
<td>1.2</td>
<td>4.4</td>
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<td>13</td>
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</tr>
<tr>
<td>Zimbabwe</td>
<td>9.2</td>
<td>0.4</td>
<td>0</td>
<td>0.3</td>
<td>5.3</td>
<td>3.2</td>
<td>5.2</td>
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<tr>
<td>High-burden countries</td>
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<td>1 580</td>
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<td>92</td>
<td>203</td>
<td>354</td>
<td>472</td>
<td>3 106</td>
</tr>
</tbody>
</table>

* Calculated as NTP budget plus cost of utilization of general health-care services.
* Numbers for South Africa estimated based on data reported in 2007.

**FIGURE 17**

Sources of funding for TB control, 21 high-burden countries, 2010a

- Government, NTP budget (excluding loans)
- Government, general health-care services (excluding loans)
- Loans (excluding Global Fund)
- Grants (excluding Global Fund)
- Global Fund

* South Africa excluded due to lack of data. Thailand data are from 2009.
6.2 High-burden countries and other countries

Besides the 22 HBCs, there are 96 other countries that have reported financial data to WHO since 2006, and which allow assessment of trends in funding for TB control. These 118 countries account for 94% of the total number of TB cases globally. In these 118 countries, funding for TB control has grown from US$ 2.7 billion in 2006 to US$ 4.1 billion in 2010 (FIGURE 19). As in HBCs, the largest share of funding is from national governments (86%), followed by the Global Fund (US$ 350 million, or 9% of total funding) and then by grants from donors besides the Global Fund (US$ 112 million, or 3%). The source of funding was unknown for the remaining 2%. Most of the available funding is in the European Region (US$ 1.9 billion, mostly in the Russian Federation), followed by the African Region (US$ 0.5 billion) and the Western Pacific Region (US$ 0.3 billion). The funding gaps identified by these 112 countries amount to US$ 0.8 billion in 2010.

A comparison of the funding available in the countries that reported financial data with the funding requirements set out in the Global Plan is provided, by region and for the period 2006–2010, in FIGURE 20.1 Overall, funding falls short of Global Plan requirements in all regions with the exception of the European Region. Outside the European Region, exceptions for which the funding reported to be available is higher than funding requirements estimated in the Global Plan are diagnosis and treatment for MDR-TB in the African Region and the Region of the Americas. Overall, the gap between the funding reported by these countries in 2010 and the funding requirements for these countries according to the Global Plan is US$ 2.1 billion. Most of the extra funding required according to the Global Plan is for MDR-TB diagnosis and treatment in the European, South-East Asia and Western Pacific regions, and for DOTS and collaborative TB/HIV activities in the African Region.

1 This analysis is for the 22 HBCs and a subset of 76 other countries that were among the 171 countries considered in the Global Plan.
FIGURE 20
Funding for TB control in 22 high-burden countries and 76 other countries, 2006–2010: the Global Plan compared with country reports.

DOTS\textsuperscript{a} includes the following line items: first-line drugs, NTP staff, routine programme management and supervision, laboratory supplies and equipment, general health-care services (including TB hospitals in the Russian Federation), PPM, PAL, ACSM and CBC.
7. Progress towards global targets for reductions in disease burden

Progress towards achieving the impact targets set for 2015 – to halt and reverse the incidence of TB by 2015, and to halve prevalence and mortality rates compared with a baseline of 1990 – is illustrated at regional level in FIGURE 21, FIGURE 22 and FIGURE 23, and at global level in FIGURE 24.

Incidence rates are declining in all nine epidemiological subregions1 with the exception of African countries with a low prevalence of HIV (FIGURE 21). The rate of decline varies, from less than 1% per year in the South-East Asia Region to around 4% per year in Latin America as well as African countries with a high prevalence of HIV; in the latter, the TB epidemic appears to have reversed in 2004 following many years of increasing TB incidence rates associated with the HIV epidemic. Globally, incidence rates peaked at 143 (range, 136–151) cases per 100,000 population in 2004. Provided the downward trend is sustained, the world as a whole is on track to achieve MDG Target 6.c.

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1 For definition of the countries included in each subregion, please refer to ANNEX.
Prevalence rates are falling in six of nine epidemiological subregions, increasing in African countries with low HIV prevalence and approximately stable in Central and Eastern European countries (FIGURE 22). Six of the nine subregions (Central Europe, Eastern Europe, the Eastern Mediterranean, high-income countries, Latin America and the Western Pacific) appear to have achieved the target of halving the 1990 prevalence rate already, well in advance of the target year of 2015. The South-East Asia region was close to the target level in 2008, and achieving the target appears feasible by 2015. Achievement of the target appears impossible in African countries.

Mortality rates (excluding TB deaths in HIV-positive people) have been falling in four of nine epidemiological subregions since 1990 (Central Europe, high-income countries, Latin America and the Western Pacific), falling since around 2003 in three regions (African countries with a high prevalence of HIV, Eastern Europe and South-East Asia), and increasing since the mid-1990s in African countries with a low prevalence of HIV (FIGURE 22). Four of the nine subregions (Central Europe, high-income countries, Latin America and the Western Pacific) appear to have achieved the target of halving the 1990 mortality rate already, well in advance of the target year of 2015. Achievement of the target in Eastern Europe, the Eastern Mediterranean and South-East Asia appears feasible. Achievement of the target appears impossible in African countries.

Globally, the gulf between prevalence and mortality rates...
Progress towards achieving the target of halving mortality rates by 2015 compared with the level of 1990 in nine subregions. Comparatively less uncertainty is attached to data points when most of the underlying aggregated data is composed of measurements from Vital Registration.

In 2008 and achieving the targets in African countries makes it unlikely that 1990 prevalence and death rates will be halved by 2015 for the world as a whole (FIGURE 24).
FIGURE 24
Global rates of TB incidence, prevalence and mortality, including in people with HIV, 1990–2008
8. Improving measurement of the global burden of TB

Estimates of TB incidence, prevalence and mortality and their trend (presented in Table 1 and in Figures 21-24) are based on the best available data and analytical methods. Methods were updated in 2009 following 18 months of work by an expert group convened under the umbrella of the WHO Global Task Force on TB Impact Measurement.\(^1\) Improvements to methods include systematic documentation of expert opinion and how this has been used in estimates of disease burden, simplification of models,\(^2\) updates to parameter values based on the results of systematic reviews, much greater use of mortality data from vital registration systems (89 countries instead of the three from which estimates were derived up to 2008) and systematic documentation of uncertainty (hence the uncertainty intervals shown on the estimates of disease burden in this report).

Despite this progress, estimates of disease burden could be substantially improved in the period up to 2015 (and beyond) with better surveillance systems, more extensive and in-depth analysis of available surveillance and programmatic data, and additional survey data. For example, with the exception of Eritrea in 2005, the last nationwide and population-based surveys of the prevalence of TB disease in the African Region were undertaken between 1957 and 1961; only around 10% of TB-attributable deaths (in HIV-negative people) are recorded in vital registration systems and reported to WHO, and most notification systems are recording only around 50–70% of estimated cases.

Besides its work on reviewing and updating the methods used to produce estimates of disease burden, the WHO Global Task Force on TB Impact Measurement is thus pursuing two other major strategic tracks of work:

- Surveys of the prevalence of TB disease in 21 global focus countries (Figure 25), carried out according to WHO guidelines and related Task Force recommendations;
- Strengthening of surveillance systems and use of surveillance data from notification and vital registration systems. The Task Force has defined a conceptual framework for this work (Figure 26) and related tools to implement it in practice.

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\(^1\) For further details, see the Task Force website at [http://www.who.int/tb/advisory_bodies/impact_measurement_taskforce/en/index.html](http://www.who.int/tb/advisory_bodies/impact_measurement_taskforce/en/index.html). The review is also the basis for the TB component of the forthcoming update to the Global Burden of Disease, due for publication in 2010.

\(^2\) For example, some parameter values are now estimated only at global level or for regions, rather than for each country individually.
As of November 2009, all of the countries in the South-East Asia and Western Pacific regions where prevalence surveys are recommended (Bangladesh, Cambodia, China, Indonesia, Myanmar, the Philippines, Thailand and Viet Nam) are on track with survey implementation. Bangladesh, the Philippines and Viet Nam have completed surveys, with subsequent surveys planned close to 2015; Cambodia and China will implement surveys in 2010, following surveys already conducted in 2002 in Cambodia and in 1990 and 2000 in China; a survey is currently under way in Myanmar and in preparation in Thailand; and in Indonesia, a follow-up to the 2004 survey is expected around 2012. In the Eastern Mediterranean Region, Pakistan has secured full funding for a survey but security concerns may preclude implementation.

The greatest challenge in terms of implementation of prevalence surveys is in the African Region. Nonetheless, considerable progress was made during 2009, with five countries now in a strong position to start surveys in 2010 (Ethiopia, Nigeria, Rwanda, South Africa and Zambia); the United Republic of Tanzania also appears in a relatively strong position to implement a survey, with all X-ray equipment already procured. Preparations are relatively advanced in Ghana, Kenya, Malawi, Mali and Uganda, but funding gaps remain a major bottleneck.

In 2009, substantial progress has been made with the analysis of surveillance and programmatic data, linked to recommendations for how surveillance systems need to be strengthened towards the ultimate goal of measuring cases and deaths directly from notification and vital registration data. Regional workshops to apply the Task Force framework (FIGURE 26) for systematic assessment of surveillance data were held for countries in the Eastern Mediterranean, European and South-East Asia regions and the Region of the Americas, covering a total of 59 countries. Similar work was also undertaken through country missions to the Philippines, the United Republic of Tanzania and Viet Nam. An important conclusion from workshops and country missions was that there is an urgent need to introduce electronic recording and reporting systems, without which it is difficult or impossible to adequately assess many aspects of data quality, and that more widespread adoption of updated recommendations on recording and reporting is required (for example, to ensure availability of data disaggregated by HIV status and source of referral). In 2010, workshops are planned for countries in the African and Western Pacific regions.

Besides improving estimates of disease burden, better data and better analysis of these data should be of great value in identifying where and why cases are not being detected and, in turn, defining which components of the Stop TB Strategy need to be introduced or scaled-up to improve TB control.
9. Conclusions

The global burden of TB is falling slowly. If current trends are sustained, the world as a whole will have achieved the MDG target of halting and reversing the incidence of TB in 2004, well in advance of 2015. Six epidemiological subregions appear to have achieved the Stop TB Partnership target of halving the 1990 prevalence rate and four appear to have achieved the Stop TB Partnership target of halving the 1990 mortality rate, in advance of the target year of 2015. Prevalence and mortality rates are falling in all other regions with the exception of African countries with a low prevalence of HIV, although reaching the global target will be difficult in the South-East Asia Region and it appears impossible in the African Region.

Reductions in disease burden achieved to date follow fourteen years of intensive efforts at global, regional and country levels to implement the DOTS strategy (1995–2005) and its successor, the Stop TB Strategy (2006–). Between 1995 and 2008, a cumulative total of 36 million TB patients were successfully treated in DOTS programmes, and up to 6 million deaths were averted. The treatment success rate achieved in DOTS cohorts worldwide exceeded the global target of 85% for the first time in 2007, reaching 86%.

Although increasing numbers of TB cases have access to high-quality treatment for TB as well as access to related interventions such as ART, much more remains to be done. More than one-third of incident TB cases are not reported as treated in DOTS programmes, around 90% of patients with MDR-TB are not being diagnosed and treated according to international guidelines, the majority of HIV-positive TB cases do not know their HIV status and most of the HIV-positive TB patients who do know their HIV status are not yet accessing ART. Funding gaps remain large, despite increases in funding since 2002.

To consolidate the major progress in global TB control achieved in recent years, intensified efforts to plan, finance and implement the range of interventions and approaches included in the Stop TB Strategy, according to the targets established in the Global Plan to Stop TB, are needed.
ANNEX

Methods used to estimate the burden of TB

1. General approach

The World Health Organization (WHO) produces estimates of the burden of TB (incidence, prevalence and mortality) annually using information gathered through surveillance systems (case notifications and death registrations), special studies (including surveys of the prevalence of disease and in-depth analyses of surveillance data), expert opinion and consultations with countries. Two recent publications provide up-to-date guidance about how TB incidence, prevalence and mortality should be measured,1,2 based on the work of the WHO Global Task Force on TB Impact Measurement (hereafter the Task Force).3 The methods used to estimate the burden of disease were updated in 2009 following 18 months of work by an expert group convened under the umbrella of the Task Force. Improvements to methods include systematic documentation of expert opinion and how this has been used to produce estimates of disease burden, simplification of models,4 updates to parameter values based on the results of systematic reviews, much greater use of mortality data from vital registration systems (89 countries instead of the three from which estimates were derived up to 2008) and systematic documentation of uncertainty (hence the uncertainty intervals shown on all of the estimates of disease burden in this report).

2. Definitions and data sources

2.1 Definition of incidence, prevalence and mortality

Incidence is defined as the number of new and relapse cases of TB (all forms) occurring in a year. Relapse cases are defined as people who have been previously treated for TB and for whom there was bacteriological confirmation of cure and/or documentation that treatment was completed. Relapse cases may be true relapses or a subsequent episode of TB caused by reinfection.

Prevalence is defined as the number of TB cases (all forms) at a given point in time. Estimates of disease burden assume that notified cases are removed from the pool of prevalent cases after a mean duration of three months (by which time most treated cases are culture-negative and would not be identified as confirmed TB cases according to standard case definitions recommended for surveys of the prevalence of TB disease5).

Mortality is defined as the number of deaths caused by TB, excluding deaths in HIV-positive TB cases, according to the definitions used in the 10th revision of the International Classification of Diseases (ICD-10). Estimates of deaths due to TB in HIV-positive cases are presented separately from estimates of deaths due to TB in HIV-negative cases.

2.2 Definition of regions

Regional analyses are generally undertaken for the six WHO regions (that is, the African Region, the Region of the Americas, the Eastern Mediterranean Region, the European Region, the South-East Asia Region and the Western Pacific Region). For analyses of epidemiological trends at the regional level, the African Region is divided into countries with low and high rates of HIV infection (with “high” defined as an infection rate of ≥4% in adults aged 15–49 years in 2004, as estimated by UNAIDS6). Central and eastern Europe (that is, countries of the former Soviet states plus Bulgaria and Romania) are also distinguished. Countries in western Europe are analysed together with other high-income countries in a category defined as Established Market Economies (EME).7 The countries within each of the resulting nine epidemiological groups or regions are listed in TABLE A1.1.

2.3 Population estimates

Where population sizes are needed to calculate TB indicators, the latest revision of estimates provided,9 by the United Nations Population Division (UNPD) is used.9 The UNPD estimates sometimes differ from those made by countries.

2.4 Sources of data on TB mortality

The best sources of data about deaths from TB (excluding those among HIV-positive people) are vital registration (VR) systems in which causes of death are coded according to the

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3 For further details, see the Task Force web site at <http://www.who.int/tb/advisory_bodies/impact_measurement_Taskforce/en/index.html>. The review is also the basis for the TB component of the forthcoming update to the Global Burden of Disease Project (<http://www.globalburden.org/>), due for publication in 2010.
4 For example, some parameter values are now estimated only at global level or for regions, rather than for each country individually.
7 As defined by the World Bank. High-income countries are those with a per capita gross national income of US$11,906 or more in 2008.
**TABLE A.1**

Nine epidemiological groups of countries and territories

<table>
<thead>
<tr>
<th>Region</th>
<th>Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Africa high-HIV</strong></td>
<td>Botswana, Burundi, Cameroon, Central African Republic, Congo, Côte d’Ivoire, Democratic Republic of the Congo, Ethiopia, Gabon, Kenya, Lesotho, Malawi, Mozambique, Namibia, Nigeria, Rwanda, South Africa, Swaziland, Uganda, United Republic of Tanzania, Zambia, Zimbabwe</td>
</tr>
<tr>
<td><strong>Africa low-HIV</strong></td>
<td>Algeria, Angola, Benin, Burkina Faso, Cape Verde, Chad, Comoros, Djibouti, Eritrea, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Madagascar, Mali, Mauritania, Mauritius, Niger, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, Sudan, Togo</td>
</tr>
<tr>
<td><strong>Central Europe</strong></td>
<td>Albania, Bosnia and Herzegovina, Montenegro, Poland, Serbia, The former Yugoslav Republic of Macedonia, Turkey</td>
</tr>
<tr>
<td><strong>Eastern Europe</strong></td>
<td>Armenia, Azerbaijan, Belarus, Bulgaria, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Republic of Moldova, Romania, Russian Federation, Tajikistan, Turkmenistan, Ukraine, Uzbekistan</td>
</tr>
<tr>
<td><strong>High-income countries</strong></td>
<td>Andorra, Antigua and Barbuda, Australia, Austria, Bahamas, Bahrain, Barbados, Belgium, Bermuda, Brunei Darussalam, Canada, Cayman Islands, China, Hong Kong SAR, China, Macao SAR, Croatia, Cyprus, Czech Republic, Denmark, Equatorial Guinea, Estonia, Finland, France, French Polynesia, Germany, Greece, Guam, Hungary, Iceland, Ireland, Israel, Italy, Japan, Kuwait, Luxembourg, Malta, Monaco, Netherlands, Netherlands Antilles, New Caledonia, New Zealand, Northern Mariana Islands, Norway, Oman, Portugal, Puerto Rico, Qatar, Republic of Korea, San Marino, Saudi Arabia, Singapore, Slovakia, Slovenia, Spain, Sweden, Switzerland, Trinidad and Tobago, United Arab Emirates, United Kingdom of Great Britain and Northern Ireland, United States of America, US Virgin Islands</td>
</tr>
<tr>
<td><strong>Eastern Mediterranean</strong></td>
<td>Afghanistan, Egypt, Iran (Islamic Republic of), Iraq, Jordan, Lebanon, Libyan Arab Jamahiriya, Morocco, Pakistan, Syrian Arab Republic, Tunisia, West Bank and Gaza Strip, Yemen</td>
</tr>
<tr>
<td><strong>Latin America</strong></td>
<td>Anguilla, Argentina, Belize, Bolivia (Plurinational State of), Brazil, British Virgin Islands, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Montserrat, Nicaragua, Panama, Paraguay, Peru, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Turks and Caicos Islands, Uruguay, Venezuela (Bolivarian Republic of)</td>
</tr>
<tr>
<td><strong>South-East Asia</strong></td>
<td>Bangladesh, Bhutan, Democratic People’s Republic of Korea, India, Indonesia, Maldives, Myanmar, Nepal, Sri Lanka, Thailand, Timor-Leste</td>
</tr>
<tr>
<td><strong>Western Pacific</strong></td>
<td>American Samoa, Cambodia, China, Cook Islands, Fiji, Kiribati, Lao People’s Democratic Republic, Malaysia, Marshall Islands, Micronesia (Federated States of), Mongolia, Nauru, Niue, Palau, Papua New Guinea, Philippines, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu, Viet Nam, Wallis and Futuna Islands</td>
</tr>
</tbody>
</table>

ICD-10. Deaths from TB in HIV-positive people are coded under HIV-associated codes.

Data from VR systems are reported to WHO by Member States and territories every year. National data on TB mortality that met the following two criteria were selected for inclusion in the Global TB database as direct measurements of TB mortality (excluding HIV):

1. The VR system included more than 70% of registered deaths; and
2. Less than 20% of causes of deaths were ill-defined.

Time-series of VR measurements that met both criteria were available for 89 countries.

### 2.5 Sources of data on TB prevalence

The best way to measure the prevalence of TB is through national population-based surveys of TB disease.\(^1\)\(^2\) Data from such surveys are available for an increasing number of countries. It should be noted, however, that measurements of prevalence are typically confined to the adult population. Furthermore, prevalence surveys exclude extrapulmonary TB as well as smear-negative and culture-negative TB.

### 2.6 Sources of data on TB incidence

No country has ever undertaken a nationwide survey of TB incidence due to the large sample sizes required and associated major logistic and financial challenges. No direct measurements of the incidence of TB are therefore available. Theoretically, data from TB information systems that are linked to health systems of high coverage and performance may capture all (or almost all) incident cases of TB. However, as yet no standard and widely-endorsed criteria and benchmarks for classifying TB surveillance systems are available (the Task Force is working on the development of such standards).

In the absence of direct measurements, estimates of TB incidence rely on expert opinion or are derived indirectly from high-quality measurements of prevalence (from surveys of the prevalence of TB disease), from high-quality measurements of mortality (from vital registration) and from special studies using capture-recapture modelling approaches.

The main sources of data used to update the 1990-2008 time series of TB incidence were:

1. Notification data for new and relapse cases;
2. Expert opinion about the coverage of the TB surveillance system, documented during four regional workshops held in 2009 in the Region of the Americas, the Eastern Mediterranean Region, the European Region and the South-East Asia Region. Expert opinion was elicited after in-depth analysis of notification data (including data...
from subnational administrative levels) and programmatic data reflecting efforts in TB control (for example, data on infrastructure, staffing, the performance of services and funding). In addition, data on access to health care from Demographic and Health Surveys and the overall performance of health systems (using indicators such as the infant mortality rate) were used to substantiate opinion on the proportion of cases with no or very limited access to health care. To facilitate the documentation of expert opinion, an “onion” framework was used in which different layers represent distinct populations of TB cases that are not captured by national TB information systems (for example, cases with no access to health care and cases with access to private health-care services but not reported to national TB control programmes [NTPs]). Surveillance data were assessed using a three-step process. This started with a systematic assessment of data quality, including an assessment of the over-dispersion of count data, followed by exploration of potential factors driving time-changes in case notifications and then by assessment of the likely number of TB cases that are not notified. These methods are documented in a workbook available on the web site of the Task Force;2

3. Measurements of prevalence from surveys of the prevalence of TB disease;
4. Measurements of TB mortality from VR systems;
5. Measurements from capture-recapture studies3 in which at least three sources of information were used (thus allowing adjustment for between-source dependencies using log-linear models); and
6. Previously published time-series of the incidence of TB. These were used for countries from the two WHO regions that were not covered by regional workshops and country visits in 2009 (the African and Western Pacific regions). The one exception was Viet Nam (in the Western Pacific Region), for which data from a recent survey of the prevalence of TB disease as well as an in-depth analysis of surveillance data were available.


3.1 From estimates of the proportion of cases detected

In countries participating in regional workshops, incidence was estimated according to the following equation:

\[
\text{incidence} = \frac{\text{case notifications}}{\text{proportion of cases detected}} - 1
\]

The proportion of cases detected, with uncertainty bounds, was estimated for three years (1997, 2003 and 2008) following in-depth analysis of national and subnational data. Incidence curves were built based on those estimates, and smoothed using a cubic splines smoother function available in the core statistics package of the R statistical environment.4 If insufficient data were available to determine the factors leading to time-changes in case notifications, incidence was assumed to follow a flat trend going through the best estimate of incidence.

In countries in the EME group, the level of TB incidence was assumed to be distributed between notification rates for combined new and relapse cases (lower uncertainty bound, noted \(l\)), and 1.3 times the notification rate (upper uncertainty bound, noted \(u\)). The country-specific and year-specific distribution of incidence was assumed to follow a log-normal distribution with standard error on the log-scale

\[
\log (\sigma) = -\frac{1}{4} \log \left( \frac{u}{l} \right)
\]

The log expected value of incidence was set at

\[
\log (\mu) = -\frac{1}{2} \log (lu).
\]

In the absence of country-specific data on the quality and coverage of TB surveillance systems, it was assumed that TB surveillance systems from countries in the EME group performed similarly well, although the model does allow for stochastic fluctuations. Updates for countries in the EME group will commence in 2010, through systematic assessments of the performance of surveillance systems, under the umbrella of special projects conducted in collaboration with partners such as the European Centre for Disease Prevention and Control and the UK Health Protection Agency.

3.2 From empirical measurements of disease prevalence

In countries where surveys of the prevalence of TB disease have been conducted, the case detection ratio (ratio of notification over incidence) \(c\) is computed according to the following equation:5

\[
c = \frac{N}{P} - 1 = \frac{N}{P + d}
\]

where \(N\) denotes notifications, \(P\) denotes prevalence and \(d\) denotes the duration of disease in non-notified cases. Durations \(d\) are assumed to follow an exponential distribution with rate \(r = 1/d\), where \(r\) is not dependent on the time from onset of disease. In undiagnosed and untreated TB, \(r\) is the sum of TB death rates and spontaneous cure rates. In treated but not notified TB cases, \(r\) is the sum of TB death rates in treated TB and the cure rate.

The duration of disease cannot be directly measured.

5 Borgdorff MW. New measurable indicator for tuberculosis case detection. Emerging Infectious Diseases, 2004, 10(9):1523–1528.
For example, measurements of the duration of symptoms in prevalent TB cases that are detected during a prevalence survey are systematically biased towards lower values, as active case-finding truncates the natural history of undiagnosed disease. Measurements of the duration of disease in notified cases ignore the duration of non-notified and untreated cases.

Literature reviews commissioned by the Task Force provide estimates of the duration of disease in untreated TB cases from the pre-chemotherapy era (that is, prior to 1940). The best estimate of the duration of disease (for smear-positive and smear-negative cases combined) in HIV-negative individuals is about three years, corresponding to a case fatality rate (CFR) of 0.34. There are few data on the duration of disease in HIV-infected individuals, and a disease duration ratio of 0.31 (0.18–0.53) in HIV-positive people as compared with HIV-negative people was used.1,2

When measurements from two prevalence surveys were available, trends in TB incidence were derived by fitting a log-linear model to indirect estimates of TB incidence. When three or more prevalence measurements were available, the incidence time-series was completed using cubic spline interpolation. If only one prevalence survey measurement was available, time-trends were assessed using in-depth analysis of surveillance data, as described above.

In this report, the prevalence to incidence method was used in only one country (Viet Nam), following a meeting in early 2009 in which consensus was reached among WHO and national experts. Similar updates to time-series of TB incidence are planned in other countries (mostly in the Western Pacific Region) in 2010.

3.3 From measurements of mortality

In three countries (Brazil, Mexico and South Africa), incidence was estimated in early 2009 from TB mortality, using the following equation:

\[
\text{incidence} = \frac{\text{deaths}}{\text{proportion of incident cases that die}}
\]

Previously published time-series of incidence for those three countries were extended to 2008, using methods described in SECTION 3.4 below.

3.4 From previously published time-series of incidence (to be phased out)

In all remaining countries, previously published time-series of TB incidence were extended by fitting a log-linear model to the estimates for 2005–2007, to predict a value for 2008. Most countries in this group will be re-assessed in 2010. Since previously published time-series of incidence did not document uncertainty ranges, lower and upper uncertainty bounds (\(u\) and \(l\) in our notation) were arbitrarily set at +/−20% of the best estimate.

Incidence estimates are no longer derived from surveys of the prevalence of TB infection as measured in tuberculin surveys. The Task Force has deemed the methods for deriving incidence from the prevalence of infection to be too unreliable. It is also doubtful whether trends in infection measured through repeat tuberculin surveys provide a reliable estimate of trends in TB incidence.

3.5 Disaggregation of estimated incident cases

Aggregated estimates of TB incidence for 2008 were distributed among 16 age and sex groups by generating multinomially distributed random number vectors and computing multinomial probabilities based on observed counts in notified cases of smear-positive TB. A similar approach was used to generate estimates of TB incidence disaggregated by smear status.

The obvious limitation of this approach is the assumption that case detection ratios are the same among all categories of case. However, there were insufficient data available to generate vectors of probabilities adjusted for varying case detection ratios among age and sex groups, and between smear-positive and smear-negative cases. It is generally thought that TB is underreported in younger age groups compared with other age groups; however, some countries are known to over-report children with a positive tuberculin reaction (but no other sign of active TB disease) as cases of TB. Furthermore, the frequency of smear-positive TB in children is less than in adults, which means that estimates tend to be biased towards low values. Greater efforts are needed to strengthen surveillance systems so that they capture more reliable data on TB in children.

To disaggregate cases by sex, the assumption of a constant case detection ratio is more robust. It is supported by comparisons of ratios of notification rates to prevalence rates that have been directly measured in surveys of the prevalence of TB disease. These show no clear evidence of systematic differences in case detection rates between men and women.3


The prevalence of HIV infection among incident cases of TB was directly estimated from country-specific and empirical data wherever possible. For the estimates published in this report, data were available for 103 countries from national surveys (42 countries), sentinel surveillance systems (20 countries) or provider-initiated testing (41 countries). Data from provider-initiated testing were used in countries where the coverage of testing was 50% or more of new and relapse cases of TB.

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For countries where surveillance data were not available or where the percentage of TB patients being tested was below 50%, the prevalence of HIV was estimated indirectly according to equation 4 (for details, see the APPENDIX), where \( t \) is HIV prevalence among incident TB cases, \( h \) is HIV prevalence in the general population (from the latest time-series provided by UNAIDS) and \( \rho \) is the incidence rate ratio (IRR) (that is, the incidence rate of TB in HIV-positive people divided by the incidence rate of TB in HIV-negative people).  

\[
t = \frac{hp}{1 + h(\rho - 1)}
\]

To estimate \( \rho \) from empirical data, equation 4 was rearranged as follows:

\[
\rho = \frac{t(1 - h)}{h(1 - t)}
\]

Using data from countries where HIV prevalence in the general population has been estimated by UNAIDS as an independent variable, a linear model of logit-transformed \( t \) was fitted using logit-transformed \( h \) (see FIGURE A.1) according to the following equation, written in matrix notation,

\[
H - T = X \hat{\theta}
\]

where \( H \) is a vector of logit(\( h \)), \( T \) is a vector of logit(\( t \)), \( X \) is an \( n \times 2 \) matrix corresponding to \( n \) \((t, h)\) data points, and two columns in which the first column holds 1s, and the second column holds an indicator variable \( g \) that equals 1 if the level of HIV in the general population exceeds 1% and is otherwise zero. The vector \( \theta \) holds two estimated model parameters, the intercept and the coefficient for \( g \). The two incidence rate ratios \( \rho \) given two levels of \( g \) are then obtained from:

\[
\rho_g = e^{\hat{\eta}^g}
\]

Models were run using Monte Carlo simulations in which \( h \) was drawn randomly from a log-linear distribution with a standard error computed as described in SECTION 3.1, with low and high uncertainty bounds as provided by UNAIDS. Quantiles of interest for the IRR where then extracted to summarize the distributions of IRR in low and high HIV-prevalence settings.

The estimated IRR for countries with a high prevalence of HIV was 20.4 (95% confidence interval 18.7-22.3) and 27.6 (26.2-29) in settings with a low prevalence of The predicted IRRs were used to calculate the prevalence of HIV in TB cases for the years 1990-2006, using equation 4, by drawing IRR values at random from a distribution assumed to be normal in Monte Carlo simulations.

The time series of HIV in TB cases was then constructed by using the empirical estimate of the IRR in 2008 (when measures for \( t \) and \( h \) were available), or by using the predicted IRR, under the assumption that the IRR did not change over time.

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1 Data on HIV prevalence in the general population are unpublished data provided to WHO by UNAIDS.

---

**FIGURE A.1**

HIV prevalence in newly notified TB cases against HIV prevalence in the general population, after logit transformation. Countries with a generalized HIV epidemic (defined here as a prevalence of HIV in the general population \( \geq 1\% \)) are depicted in blue and other countries are shown in red. Horizontal and vertical segments represent 95% confidence intervals of HIV estimates in the general population and measurements of HIV among TB cases, respectively. A linear regression model was fitted to the logit-transformed data.

Three important limitations of these methods are:

- The assumption that the IRR is time-independent. This is likely to result in increasingly biased estimates (towards high values) of the burden of HIV in TB the further back in time the estimates go.
- There is no specific accounting for the protective effect of ART on the incidence of TB. Since measurements are taken in populations with various levels of access to ART, the 2008 empirically measured IRRs do incorporate the effect of ART to some extent. However, estimates prior to 2008 are likely to be biased, since in these years the coverage of ART was lower. Here, the bias is towards lower values.
- Measurements of \( t \) used to estimate the IRR were assumed to be known with no error. In several countries, reports of HIV infection in TB cases include HIV test results obtained during the course of or towards the end of TB treatment. Rates of coinfection are therefore among survivors with a lower probability of HIV infection. As the coverage or provider-initiated testing increases towards 100% of new and relapse TB cases, the quality of such measurements will improve.

Mortality measurements from VR systems in 89 countries that met the criteria defined in SECTION 2.4 were adjusted to account for incomplete coverage. This was done by assuming that the distribution of causes of deaths in non-coded deaths was similar to that in coded deaths. In addition, 50% of the deaths with ill-defined causes were proportionately redistributed among known TB causes, with the assumption that there was a lower likelihood that an ill-defined death was an actual TB death. Errors in measurements (misclassifications) and assumptions (redistributions) were assumed to be log-normally distributed with a standard deviation on the log scale \( \sigma = \frac{0.05 \mu}{\sqrt{\nu + s/2}} \)

where \( \mu \) is the mortality measurement, \( \nu \) the coverage of the VR system and \( s \) is the rate of ill-defined codes. In other words, the standard deviation was arbitrarily inflated in proportion to VR coverage and ill-defined causes of death.

The number of deaths from TB is estimated by multiplying the incidence of TB in each year by the estimated CFR. Separate CFRs were used for four categories of case: notified or not, and infected with HIV or not. Furthermore, separate CFR distributions were used for non-notified cases in countries in the EME group to account for the comparatively lower likelihood that cases remain untreated, and for notified cases in eastern Europe to account for the higher burden of multidrug-resistant TB (MDR-TB) and associated higher CFRs.

A Bayesian approach was used to generate time-series of TB mortality. First, prior distributions of CFRs were used to generate mortality time-series for the 89 countries where mortality measurements from VR systems were available and where those measurements met the quality criteria described in SECTION 2.4. Parameter distributions for CFRs were then adjusted globally in an iterative process, to maximize the median posterior mortalities going through uncertainty bands of VR measurements of mortality, in a process where the outcome to be predicted was constrained within a plausible range of values.

Limitations of this method include:
- The use of global distributions of CFRs and the assumption that posterior CFRs for countries with VR measurements apply to other countries. Countries with VR measurements are likely to be different from countries where no VR mortality measurements are available. It is hoped that strengthened efforts to measure TB mortality directly, either through VR systems or from interim systems such as sample VR combined with well-designed autopsy studies will improve our understanding of CFRs.
- Aggregated mortality estimates were distributed among 16 age and sex groups by generating multinomially distributed random number vectors, and then computing multinomial probabilities based on observed counts in notified cases of smear-positive TB. The obvious limitations here are that CFRs are constant across case categories, and that the distribution of deaths in age and sex groups mirrors the distribution of cases of new smear-positive TB. Insufficient data were available to adjust vectors of probabilities to account for varying CFRs. In-depth analysis of age-specific mortality rates will be carried out in 2010 to improve our understanding of the variation in case fatality among age groups.


Entries into the pool of prevalent cases come from incidence multiplied by the size of the susceptible population. Exits from the pool occur as a result of death, self-cure in undiagnosed cases, cure from non-notified treatments, and notification. In our model, notified cases are removed from the pool of prevalent cases. Distributions of the duration of disease are used for non-notified cases (the group of non-notified cases include undiagnosed cases and cases that are diagnosed and treated but not notified to NTPs). The distributions used are described in SECTION 3.2.

Our model ensures full consistency in the estimation of TB incidence from the prevalence of TB and estimation of the prevalence of TB from TB incidence. However, the model specification is based on some assumptions that may be violated in reality. In particular, the time-independence of the rate of removal from the pool of prevalent cases is unlikely to hold in practice; however, this assumption has been made in almost all publications of dynamic models of TB, since the country-specific data necessary to appropriately model time-dependencies are generally not available. The model is described in FIGURE A.2.

Equation 2 can be rearranged as follows:

\[
P = \frac{Nd}{c}(1 - c)
\]

Prevalence numbers were inflated by assuming a delay of three months when moving to the compartment of notified cases, with bounds of two and four months.

\[\text{FIGURE A.2}\]

Model of TB case detection. The arrows depict rates of cases moving from one compartment to the other.
7. Estimation of uncertainty

There are many potential sources of uncertainty associated with estimates of TB incidence, prevalence and mortality, as well as estimates of the burden of HIV-associated TB and MDR-TB. These include uncertainties in input data, in parameter values, in extrapolations used to impute missing data, and in the model used.

We used fixed population values from the UNPD. Although these values have uncertainty attached to them, we did not account for it.

Notification data are of uneven quality. Cases may be underreported (missing quarterly reports from remote administrative areas are not uncommon), misclassified (in particular, misclassification of relapse cases in the category of new cases is common), or over-reported as a result of duplicated entries in TB information systems. The latter two issues can only be addressed efficiently in countries with case-based nationwide TB databases that include patient identifiers. Sudden changes in notifications over time are often the result of errors or inconsistencies in reporting, but may sometimes reflect abrupt changes in TB epidemiology (for example, resulting from a rapid influx of migrants from countries with a high-burden of TB, or from rapid improvement in case-finding efforts). Missing national aggregates of new and relapse cases were imputed by cubic spline interpolation; however, notification trajectories were not automatically smoothed over time, to avoid introducing systematic errors in countries where time-changes are reflecting true changes in the epidemiology of TB. Attempts to obtain corrections for historical data are made every year, but only rarely do countries provide appropriate data corrections. It is therefore generally unclear when bumps in notifications are most likely reflecting reporting errors. Future regional workshops will include a systematic effort to correct for such data deficiencies using expert opinion, for those cases where corrections appear necessary.

Model parameter values are described in Table A.2.

The model used the following sequence: (1) incidence estimation, (2) estimation of IRRs for TB/HIV, (3) estimation of HIV prevalence among incident cases, (4) estimation of mortality, (5) estimation of prevalence, and (6) distribution of incident cases and deaths among age and sex groups. By design, some steps were independent from each other (e.g. step 4 may be done before or after step 5).

The general approach to uncertainty analyses was to draw values from specified distributions for every parameter (except for notifications and population values) in Monte Carlo simulations, with the number of simulation runs set so that they were sufficient to ensure stability in the outcome distributions. The same random number generator seed was used for every country, and errors were assumed to be time-dependent within countries (thus generating autocorrelation in time-series). Regional parameters were used in some instances (for example, for CFRs).

Summaries of quantities of interest were obtained by extracting the 2.5, 50 and 97.5 centiles of posterior distributions.

Regional and global aggregated summaries for incidence, prevalence and mortality were obtained by aggregating country-specific distributions.

### Table A.2

#### Model parameter estimates

<table>
<thead>
<tr>
<th>Model Parameter</th>
<th>Distribution</th>
<th>Distribution Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidence Established Market Economies</td>
<td>Log-normal</td>
<td>$\log(\mu) = \frac{1}{4} \log \left( \frac{u}{l} \right)$</td>
</tr>
<tr>
<td>HIV prevalence (general population)</td>
<td>Log-normal</td>
<td>$\log(\mu) = \frac{1}{2} \log (lu)$</td>
</tr>
<tr>
<td>HIV prevalence (incident TB)</td>
<td>Log-normal</td>
<td>$\log(\mu) = \frac{1}{4} \log \left( \frac{u}{l} \right)$</td>
</tr>
<tr>
<td>Duration non-notified HIV-negative</td>
<td>Triangular</td>
<td>Mode=3; l=2; u=4</td>
</tr>
<tr>
<td>Duration ratio HIV-negative/HIV-positive</td>
<td>Log-normal</td>
<td>$\mu = e^{0.31}$; $\sigma = e^{0.2}$</td>
</tr>
<tr>
<td>Case fatality rate non-notified HIV-negative</td>
<td>Triangular</td>
<td>Mode=0.3; l=0.05; u=0.7</td>
</tr>
<tr>
<td>Case fatality rate non-notified HIV-negative, group of Established Market Economies</td>
<td>Triangular</td>
<td>Mode=0.07; l=0.02; u=0.2</td>
</tr>
<tr>
<td>Case fatality rate notified HIV-negative</td>
<td>Triangular</td>
<td>Mode=0.05; l=0.01; u=0.12</td>
</tr>
<tr>
<td>Case fatality rate notified HIV-negative, Eastern European Group</td>
<td>Triangular</td>
<td>Mode=0.1; l=0.04; u=0.2</td>
</tr>
<tr>
<td>Case fatality rate non-notified HIV-positive</td>
<td>Triangular</td>
<td>Mode=0.4; l=0.2; u=0.9</td>
</tr>
<tr>
<td>Case fatality rate non-notified HIV-positive, group of Established Market Economies</td>
<td>Triangular</td>
<td>Mode=0.2; l=0.01; u=0.5</td>
</tr>
<tr>
<td>Case fatality rate notified HIV-positive</td>
<td>Triangular</td>
<td>Mode=0.25; l=0.1; u=0.5</td>
</tr>
<tr>
<td>Case fatality rate notified HIV-positive, group of Established Market Economies</td>
<td>Triangular</td>
<td>Mode=0.15; l=0.05; u=0.3</td>
</tr>
</tbody>
</table>

* $u$ and $l$ denote upper and lower uncertainty bounds
Appendix: Deriving the prevalence of HIV in incident TB from the prevalence of HIV in the general population

The following notation is used in this appendix:

- \( N \) denotes the population size during one year;
- \( I \) denotes incident TB cases occurring over one year;
- subscript \( + \) indicates HIV-infected;
- subscript \( - \) indicates HIV-negative. Therefore, \( I_+ / N_+ \) is the incidence of TB in HIV-positive adults and \( I_- / N_- \) is the incidence of TB in HIV-negative adults.

The incidence rate ratio \( \rho \) (the ratio of incidence of TB in HIV-positive adults to the incidence of TB in HIV-negative adults) is defined as follows:

\[
\rho = \frac{I_+ / N_+}{I_- / N_-}
\]

we can rearrange to get:

\[
\rho \cdot \frac{I_-}{I_+} = \frac{I_+}{N_+} \]

then:

\[
\rho \cdot \frac{I_-}{I_+} = \frac{N_-}{N_+}
\]

to the top of the left hand side we add and subtract \( I_+ \), to the right hand side we add and subtract \( N_+ \):

\[
\rho \frac{I_+ + I_- - I_+}{I_+} = \frac{N_+ + N_- - N_+}{N_+}
\]

since \( I_+ + I_- = I \) and \( N_+ + N_- = N \) we can simplify as follows:

\[
\rho \left( \frac{I_-}{I_+} \right) = \frac{N}{N_+} - 1
\]

multiplying out the LHS,

\[
\rho \frac{I_-}{I_+} = \frac{N}{N_+} - 1,
\]

then dividing through by \( \rho \):

\[
\frac{I_-}{I_+} = \left( \frac{N}{N_+} - 1 + \rho \right) / \rho
\]

inverting both sides:

\[
t = \frac{\rho}{h} = \frac{h \rho}{1 + h(\rho - 1)}
\]

where \( h = N_- / N \) denotes HIV prevalence in adults and \( t = I_- / I \) denotes HIV prevalence in new adult TB cases.
The World Health Organization monitors the global tuberculosis epidemic in support of national TB control programmes.

For further information about tuberculosis contact:
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