Tuberculosis prevalence in China, 1990–2010; a longitudinal analysis of national survey data

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Summary

Background China scaled up a tuberculosis control programme (based on the directly observed treatment, short-course [DOTS] strategy) to cover half the population during the 1990s, and to the entire population after 2000. We assessed the effects of the programme.

Methods In this longitudinal analysis, we compared data from three national tuberculosis prevalence surveys done in 1990, 2000, and 2010. The 2010 survey screened 252 940 eligible individuals aged 15 years and older at 176 investigation points, chosen by stratified random sampling from all 31 mainland provinces. All individuals had chest radiographs taken. Those with abnormal radiographs, persistent cough, or both, were classified as having suspected tuberculosis. Tuberculosis was diagnosed by chest radiograph, sputum-smear microscopy, and culture. Trained staff interviewed each patient with tuberculosis. The 1990 and 2000 surveys were reanalysed and compared with the 2010 survey.

Findings From 1990 to 2010, the prevalence of smear-positive tuberculosis decreased from 170 cases (95% CI 166–174) to 59 cases (49–72) per 100 000 population. During the 1990s, smear-positive prevalence fell only in the provinces with the DOTS programme; after 2000, prevalence decreased in all provinces. The percentage reduction in smear-positive prevalence was greater for the decade after 2000 than the decade before (57% vs 19%; p<0·0001). 70% of the total reduction in smear-positive prevalence (78 of 111 cases per 100 000 population) occurred after 2000. Of these cases, 68 (87%) were in known cases—ie, cases diagnosed with tuberculosis before the survey. Of the known cases, the proportion treated by the public health system (using the DOTS strategy) increased from 59 (15%) of 370 cases in 2000 to 79 (66%) of 123 cases in 2010, contributing to reduced proportions of treatment default (from 163 [43%] of 370 cases to 59 cases [49–72] per 100 000 population). During the 1990s, smear-positive prevalence fell only in the provinces with the DOTS programme; after 2000, prevalence decreased in all provinces.

Interpretation In 20 years, China more than halved its tuberculosis prevalence. Marked improvement in tuberculosis treatment, driven by a major shift in treatment from hospitals to the public health centres (that implemented the DOTS strategy) was largely responsible for this epidemiological effect.

Funding Chinese Ministry of Health.

Introduction In 2010, China had an estimated 1 million new tuberculosis cases, accounting for 11% of global tuberculosis incidence.1 The country began to address its tuberculosis problem on a large scale in the 1990s when a tuberculosis control project, containing key elements of the internationally recommended directly observed treatment, short-course (DOTS) strategy (hereafter called the DOTS programme), was implemented in 13 provinces containing half the country’s population.2 Two national surveys of the prevalence of tuberculosis—done in 1990 and 2000—showed a 30% increased reduction in tuberculosis prevalence in areas that implemented this project.3 However, the national tuberculosis prevalence fell by less than 20% in 10 years; this slight reduction could be because, at its peak, the project treated only 30% of the estimated new smear-positive tuberculosis cases in the country.4 To accelerate the national tuberculosis control effort, the State Council of China issued a new 10-year tuberculosis control plan in 2001, which expanded the DOTS programme to the entire country by 2005. A previous report detailed the measures developed and implemented by the government to increase the number of tuberculosis patients treated in the DOTS programme.5 Through these efforts, China achieved the 2005 global tuberculosis control targets of detecting at least 70% of all estimated new smear-positive tuberculosis cases and successfully treating more than 85% of these patients—the only country with a high tuberculosis burden to achieve this.6,7 To re-evaluate China’s tuberculosis burden, a national tuberculosis prevalence survey was done in 2010. We report the main findings of the latest survey and compare the results with those from the 1990 and 2000 surveys;8 this analysis allowed us to assess the effects of 20 years of tuberculosis control.

Methods

Survey design We undertook a longitudinal analysis of data from 1990, 2000, and 2010 national tuberculosis prevalence surveys in China. For the 2010 survey, we used multistage, stratified sampling to randomly select 176 investigation points from within the 31 mainland provinces, municipalities, and...
Patients and procedures

All participants had chest radiographs taken. Those with cough for greater than 2 weeks or haemoptysis were classified as having symptoms of tuberculosis (figure 1). We collected sputum from individuals with any of the four following characteristics: tuberculosis symptoms, an abnormal chest radiograph, a diagnosis of tuberculosis before the survey, and a pregnant woman or person with restricted mobility who were not examined by chest radiography. Three sputum specimens (spot, night, and morning) were collected for smear microscopy and two specimens were cultured on Löwenstein–Jensen medium. The selection of specimens for culture was based on the level of smear positivity and appearance.

A positive smear had at least one acid-fast bacillus identified during examination of 100 fields. Slides were reviewed by a central team of experts, and only those identified as positive on both initial and repeat examinations were classified as positive. A positive culture had at least one colony of *Mycobacterium tuberculosis* complex isolated. Bacteriologically positive cases were those with at least one positive smear or culture. Smear and culture were done at a tuberculosis laboratory in either the city or county closest to the investigation site. These laboratories had technicians trained to undertake tuberculosis testing according to national guidelines and participated in internal and external quality assurance programmes for smear microscopy. During the survey period, a provincial tuberculosis reference laboratory closely monitored the quality of the sputum culture and provided assistance to laboratories whenever culture contamination exceeded 5% or the percentage of negative culture in the smear-positive specimens exceeded 10%. Cultures with growing colonies were sent to the National Tuberculosis Reference Laboratory for identification.

Patients with active tuberculosis included those with bacteriologically-positive sputum and those diagnosed only by changes on their chest radiographs. Therefore, individuals with active tuberculosis included patients with smear-positive and culture-negative sputum, smear-negative but culture-positive sputum, and smear-negative and culture-negative sputum. Survey staff were trained to diagnose active tuberculosis cases on the basis of patient symptoms and clinical history, radiographic findings, bacteriological results, and response to antibiotics, in accordance with national guidelines. A national expert group reviewed the data from each patient to confirm the diagnosis.

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Newly identified cases were separated from known, or previously diagnosed, cases that were still active at the time of the survey. The sampling approach and the clinical and laboratory methods for diagnosis of tuberculosis in the 2010 survey were the same as those used in the 1990 and 2000 surveys, but were done at different investigation sites and by different survey teams than those in 2010.

Trained staff administered a standard questionnaire to every person with tuberculosis. People with a previous diagnosis of tuberculosis, were classified as known cases and were asked questions about their past and present diagnosis and treatment. For the known cases, we checked the tuberculosis registry of the public health system to establish whether the patient had been reported to, and registered in, the Chinese Center for Disease Control and Prevention (CDC) system.

**Previous surveys**

Although the 1990 and 2000 surveys had similar designs, they differed in some areas.\(^7\) First, both the 1990 and 2000 surveys included testing for individuals aged autonomous regions (hereafter termed provinces). We sampled urban and rural sites separately to ensure the survey had 77 urban and 99 rural investigation points, in line with the urban: rural ratio of the national population. All people aged 15 years or older and a local resident (defined as residing in the survey area for at least 6 months) were eligible for the survey. Each investigation point averaged 1503 people. The survey was done from April, 2010, to July, 2010. The survey design is consistent with global guidelines.\(^7\) The study was reviewed and approved by the Tuberculosis Operational Research Ethics Review Committee of Chinese Ministry of Health; the need for individual informed consent was waived by the committee.

**Patients and procedures**

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The survey was designed to detect an annual decline in national prevalence of smear-positive tuberculosis between 2000 and 2010 with a probability of greater than 95% and power of 95%. This rate of decline was observed in areas implementing the DOTS strategy from 1990 to 2000. We calculated the sample size to be 264,630 with simple random sampling, a design effect of 1.8 from the 2000 survey, and 90% participation rate. Although the survey was not designed a priori to compare subpopulations within China, we stratified the data in several ways: sex, age, urbanisation (urban and rural), region (western, central, and eastern parts of the country), and provinces that implemented the DOTS programme in the 1990s and after 2000.

We calculated the overall prevalence rates and the stratum-specific rates for various subpopulations and analysed patient information using the complex survey module in SPSS Statistics 17.0. This module takes into account the clustered sampling design of the survey. CIs were adjusted for the cluster design by the Taylor series linearisation. When comparing prevalences in different subpopulations and over time, we adjusted p values using the second-order correction of Rao–Scott for the χ² test. The difference or change in prevalence was assumed to follow a beta distribution. Two shape parameters needed to define the β distribution were computed using the method of moments. The upper and lower 2.5% of the resulting distribution were used to determine the 95% CI. We did these computations using R statistical package (2.15.1).

Role of the funding source
The sponsor of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The Chinese CDC operates under the general guidance of the Ministry and was responsible for the design, implementation, and analysis of the 2010

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<tbody>
<tr>
<td><strong>All provinces</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>All pulmonary</td>
<td>661 (653 to 669)</td>
<td>414 (390 to 439)</td>
<td>442 (417 to 469)</td>
<td>-32% (-36 to -28)</td>
</tr>
<tr>
<td>Bacteriologically positive</td>
<td>221 (216 to 226)</td>
<td>178 (163 to 195)</td>
<td>116 (101 to 132)</td>
<td>-19% (-27 to -12)</td>
</tr>
<tr>
<td>Smear positive</td>
<td>170 (166 to 174)</td>
<td>137 (123 to 153)</td>
<td>59 (49 to 72)</td>
<td>-19% (-28 to -10)</td>
</tr>
</tbody>
</table>

**Provinces that implemented DOTS in 1990s**:  
- All pulmonary: 665 (653 to 667) | 364 (335 to 395) | 402 (323 to 505) | -45% (-50 to -40) | 27% (12 to 44) | -31% (-37 to -24) |
- Bacteriologically positive: 239 (232 to 246) | 154 (135 to 174) | 110 (93 to 130) | -36% (-44 to -27) | -29% (-43 to -12) | -54% (-62 to -46) |
- Smear positive: 176 (170 to 182) | 113 (96 to 133) | 63 (50 to 80) | -36% (-46 to -24) | -44% (-59 to -26) | -64% (-72 to -55) |

**Provinces that implemented DOTS after 2000**:  
- All pulmonary: 663 (652 to 674) | 499 (459 to 542) | 443 (411 to 478) | -25% (-31 to -18) | -31% (-21 to 0) | -33% (-38 to -28) |
- Bacteriologically positive: 225 (219 to 231) | 219 (194 to 248) | 124 (101 to 152) | -3% (-15 to 10) | -43% (-56 to -28) | -45% (-56 to -33) |
- Smear positive: 180 (174 to 186) | 174 (151 to 201) | 59 (43 to 79) | -3% (-17 to 12) | -66% (-76 to -53) | -67% (-77 to -56) |

Data are mean (95% CI) for individuals aged 15 years and older. DOTS=direct observed treatment, short-course. *Negative values show decrease in prevalence. †Data analysed with 1990 diagnostic protocol, except chest radiograph used in initial screening instead of fluoroscopy in 2010; results unstandardised for age or other variables. ‡Provinces that implemented DOTS in 1990s include Chongqing, Gansu, Guangdong, Hainan, Hebei, Heilongjiang, Hebei, Hunan, Liaoning, Ningxia, Shandong, Sichuan, and Xinjiang; provinces that implemented DOTS after 2000 include Anhui, Fujian, Guangxi, Guizhou, Henan, Hebei, Hefei, Jiangxi, Jiangsu, Jilin, Neimeng, Qinghai, Shaanxi, Shanxi, Tibet, Yunnan, and Zhejiang. The three municipalities of Beijing, Shanghai, and Tianjin are excluded from this analysis because, for more than 30 years, they have had high economic development, substantial expertise in tuberculosis control, and organised tuberculosis control programmes similar to the DOTS programme.

Table 1: Comparison of tuberculosis prevalence over time in provinces that implemented DOTS in 1990s and after 2000
survey. LW, HZ, YR, YX, and DPC had complete access to the data and were responsible for submitting the Article for publication.

**Results**

Of 263,281 individuals eligible in 2010, 252,940 (96%) participated in the survey, 4,541 (2%) refused to participate, 3,709 (1%) were not at the investigation site during the survey, and 2,091 (1%) did not participate for other reasons. Of 9,825 people eligible for sputum examination, 9,716 (99%) had examination results, and 109 (1%) did not submit sputum samples. With the 2010 diagnostic protocol, 1,310 cases of active pulmonary tuberculosis were detected, of which 347 were bacteriologically positive (119 per 100,000 population; 95% CI 103–135) and 188 were sputum smear-positive (66 per 100,000 population; 95% CI 53–79).

From 1990 to 2010, smear-positive prevalence fell by 65%, bacteriologically positive prevalence declined by 48%, and prevalence of all pulmonary cases declined by 28% (table 1). 70% of the reduction in smear-positive prevalence and 59% of the reduction in bacteriologically-positive prevalence occurred after 2000.

From 1990 to 2000, provinces that implemented the DOTS programme had a significant reduction in the prevalence of smear-positive and bacteriologically positive tuberculosis cases; other provinces did not have this reduction (table 1). From 2000 to 2010, these prevalences decreased in both groups of provinces, reaching roughly the same level by 2010; this resulted from a greater (although not statistically significant) reduction in provinces that implemented DOTS after 2000.

The reduction in prevalence of smear-positive and bacteriologically positive tuberculosis cases was largely due to a reduction in the prevalence of known cases (figure 2). From 2000 to 2010, the prevalence of smear-positive tuberculosis among known cases decreased by 88% (from 77 to 9 per 100,000 population). This decrease accounted for 87% of the total reduction in smear-positive prevalence (68 of 78 per 100,000 population).

From 2000 to 2010, the prevalence of bacteriologically positive tuberculosis decreased significantly in all subpopulations examined, including men, women, all age groups, urban and rural areas, and all regions except western China (table 2). The reduction in prevalence was significantly less in western than in eastern China (p=0.0026), but not significantly different between strata in other subpopulations.

**Table 2:** Change in the prevalence of bacteriologically positive tuberculosis in subpopulations, 2000 and 2010

<table>
<thead>
<tr>
<th>Region</th>
<th>Prevalence per 100,000 population*</th>
<th>Change, 2000–2010 (%)†</th>
</tr>
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<tbody>
<tr>
<td>Eastern</td>
<td>158 (137 to 183)</td>
<td>66 (52 to 84)</td>
</tr>
<tr>
<td>Central</td>
<td>241 (203 to 285)</td>
<td>124 (92 to 166)</td>
</tr>
<tr>
<td>Western</td>
<td>262 (228 to 302)</td>
<td>212 (180 to 249)</td>
</tr>
</tbody>
</table>

Data are mean (95% CI) for individuals aged 15 years and older. *Data analysed with 2000 diagnostic protocol, except chest radiograph used in initial screening instead of fluoroscopy in 2010, and unstandardised for age or other variables. †Negative values show decrease in prevalence. Eastern provinces include Anhui, Heilongjiang, Henan, Hunan, Hubei, Jiangsu, Zhejiang, and Shanghai; central provinces include Hebei, Heilongjiang, Henan, Hunan, Hubei, Jiangsu, Zhejiang, and Shanxi; western provinces include Chongqing, Gansu, Guangxi, Guizhou, Neimeng, Ningxia, Qinghai, Shaanxi, Sichuan, Tibet, Xinjiang, and Yunnan.
From 2000 to 2010, substantial programmatic improvements occurred. More patients were reported to, and registered with, the CDC system. The percentage of patients defaulting from treatment decreased from 43% (163 of 370) to 22% (35 of 123), and the percentage of retreatment cases decreased from 84% (312 of 374) to 31% (312 of 123) (p<0.0001). This resulted from an increase in the proportion of patients treated by the CDC system and, to a lesser extent, from treatment improvement in both the CDC and the hospital systems (table 3). Among known cases, the proportion treated by the CDC system (using the DOTS strategy) increased from 59 (15%) of 370 in 2000 to 79 (66%) of 123 in 2010. However, in 2010, half of the patients diagnosed in the hospital system still had not been reported to the CDC and nearly half of those treated by hospitals had defaulted from treatment.

The programmatic improvements from 1990 to 2000 were fairly minor. The proportion of tuberculosis cases reported to the CDC system increased from 460 (19%) of 2453 to 93 (23%) of 374 (p=0.0055); the proportion of patients who received tuberculosis treatment increased from 2313 (94%) of 2453 to 370 (99%) of 374 (p=0.00014), and the proportion of patients who defaulted from treatment decreased from 1118 (51%) of 2202 to 370 (43%) of 818 (p<0.0168). Calculation of the above percentages took into account the sampling design and therefore might not be reproducible simply from data in the table. Few patients were not treated in the type of institution where they were diagnosed. Denominator for regularity of drug intake is the number of patients started on treatment; denominator for reasons for defaulting is the number of patients defaulted from treatment.

Data are N or n (%). CDC=Centers for Disease Control. Calculation of percentages takes into account the multistage, stratified sampling design, therefore the percentages presented in the table might not be reproducible simply from data in the table. *Few patients were not treated in the type of institution where they were diagnosed. ‡Denominator for regularity of drug intake is the number of patients started on treatment; denominator for reasons for defaulting is the number of patients defaulted from treatment.

### Table 3: Reporting and treatment of previously diagnosed tuberculosis cases by where patients were diagnosed and treated, 2000 and 2010

<table>
<thead>
<tr>
<th>Reason for defaulting from treatment‡</th>
<th>2000</th>
<th>2010</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regularally</td>
<td>0.0335</td>
<td>0.0002</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Late diagnosis</td>
<td>0.4858</td>
<td>0.2048</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Missed appointments</td>
<td>0.4858</td>
<td>0.2048</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Other</td>
<td>0.4858</td>
<td>0.2048</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Financial difficulties</td>
<td>0.4858</td>
<td>0.2048</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Side-effects</td>
<td>0.4858</td>
<td>0.2048</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Others</td>
<td>0.4858</td>
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### Discussion

From 1990 to 2010, for individuals aged 15 years and older in China, the prevalence of smear-positive tuberculosis fell by 65% and the prevalence of bacteriologically positive tuberculosis fell by 48% (panel). By 2010, China had thus achieved one of the key global tuberculosis targets set by the Stop TB Partnership: to reduce the prevalence of smear-positive tuberculosis by 50%. This reduction was achieved 5 years before the target date of 2015. This analysis did not include data from individuals younger than 15 years; however, the absence of such data is unlikely to change the major findings because less than 2% of laboratory confirmed tuberculosis cases come from this age group.

The reduction in tuberculosis prevalence occurred concurrently with the scale-up of the DOTS programme in China. This scale-up, which was implemented by the CDC system through its local public health clinics, occurred in two distinct phases. During the 1990s, the country expanded the DOTS programme to cover half of its population, and increased the tuberculosis case detection rate—the percentage of all estimated new smear-positive tuberculosis patients detected—to roughly 30%. Concurrently, the prevalence of smear-positive tuberculosis fell by 19%. From 2001 to 2005, China scaled up the DOTS programme nationwide and used a series of public health interventions to increase the tuberculosis case detection rate to nearly 80%. The prevalence of smear-positive tuberculosis fell by 57% for the decade after 2000—tripling the reduction of the previous decade. 70% of the absolute reduction in smear-positive prevalence in two decades occurred during the second decade when tuberculosis control efforts intensified.

Even though the prevalence of smear-positive tuberculosis decreased significantly during the 1990s, the change was only seen in areas of China where the DOTS programme was implemented. After adjustments for changing age structure and other factors, a previous analysis attributed a 30% reduction in tuberculosis prevalence to the DOTS programme, supporting a
importance of addressing of poor tuberculosis treatment in the hospital system.巨大改进提高了肺结核的治疗水平，显示出该国结核病的流行病学效应超出了目标日期。事实上，中国实现了结核病发病率减少了57%。这一研究显示，在DOTS项目实施后的10年里，菲第二轮结核病流行病学调查结果显示有31%的结核菌涂片阳性患者在治疗过程中有菌活性，且结核菌涂片阳性的发病率下降了27%。然而，结核菌涂片阳性的发病率下降并不显著。一项全球结核病防治目标旨在将结核病发病率在2010年之前减少50%。这项研究显示，中国在2000年到2010年的5年时间里，结核菌涂片阳性的发病率下降了57%。在中国，结核菌涂片阳性的发病率从2000年到2010年下降了10年，与DOTS项目实施规模一致。此外，这项研究还考察了DOTS项目在提高结核病治疗水平方面的效果，以及这一重要问题在医院系统中的作用。

我们从2000年到2010年的时间里收集了信息，在治疗过程中有菌活性的患者中，有80%的患者按时服药，有30%的患者在治疗过程中有菌活性。2000年时，有80%的患者按时服药，而到2010年时，有66%的患者按时服药。如果没有这些变化，大部分患者将无法继续使用CDC系统。通过扩大免费治疗政策的覆盖面，使更多的患者能够访问CDC系统。

这两次变化，即结核病发病率下降了15%到66%。通过这些变化，大多数患者可以继续在医院系统中访问CDC系统。这表明，DOTS项目在国家层面上提高了肺结核的治疗水平。

此外，在中国，没有其他国家有较高的结核病发病率。如DOTS项目在国家层面上提高了肺结核的治疗水平。然而，结核菌涂片阳性的发病率下降并不显著。一项全球结核病防治目标旨在将结核病发病率在2010年之前减少50%。这项研究显示，中国在2000年到2010年的5年时间里，结核菌涂片阳性的发病率下降了57%。在中国，结核菌涂片阳性的发病率从2000年到2010年下降了10年，与DOTS项目实施规模一致。此外，这项研究还考察了DOTS项目在提高结核病治疗水平方面的效果，以及这一重要问题在医院系统中的作用。
trained health-care workers, and weaker public health infrastructure to address a problem such as tuberculosis. Increased governmental inputs are needed to improve tuberculosis control efforts in these areas.

Second, the reporting and treatment of patients with tuberculosis in the hospital system should be improved. In 2010, fewer than half of the cases diagnosed in hospitals were reported to, and registered in, the CDC system, and only 41% of patients started on treatment in hospitals were taking their drugs regularly when in the community. Furthermore, use of improper treatment regimens in hospitals is widespread.13

Third, the DOTS programme has been much more effective in reducing the prevalence of tuberculosis in known cases than in new cases. Because the prevalence in known cases is already very low, future reduction in tuberculosis prevalence is likely to slow substantially unless control efforts in addition to the DOTS strategy are implemented, especially in earlier case detection and treatment and use of new instruments.8,13 Future studies can help to identify populations at high risk of tuberculosis and assess the feasibility and effectiveness of active case-finding or preventive treatment. China already has a policy to screen individuals with HIV for tuberculosis, and the use of preventive treatment is being evaluated. Although more should be done to prevent HIV-associated tuberculosis, such efforts will not have a major effect on the overall reduction in tuberculosis prevalence given the fairly small and concentrated HIV epidemic in the country.16,17

An intriguing finding is the absence of reduction in the prevalence of all pulmonary cases between 2000 and 2010. We believe this absence is due to the use of chest radiography as the initial screening instrument in 2010 instead of chest fluoroscopy in the earlier surveys. This change in instrument probably increased the sensitivity of case detection in 2010, thus masking any real decrease in the prevalence of pulmonary cases.

There are several limitations to our study. First, chest radiographs were used to screen the survey population in 2010, whereas fluoroscopy was used in earlier surveys. The 2010 survey was therefore more sensitive in identifying patients with tuberculosis. However, the reductions in this study would have been greater if fluoroscopy had been used in 2010 instead of chest radiographs. Second, we excluded individuals younger than 15 years from this analysis. Because the proportion of the Chinese population in this age group has been decreasing, to include them in our analysis would have reduced (albeit by a very small amount) the decrease of tuberculosis prevalence in the entire population. Third, socioeconomic development probably contributed to the reduction in tuberculosis prevalence, but its effects cannot be distinguished from tuberculosis control efforts. However, its contribution was unlikely to have varied greatly with time because the annual growth in gross domestic product per head adjusted for purchasing power parity was 10% between 1990 and 2000 and 11% between 2000 and 2010. During this 20 years of steady economic growth, the observed correlation between intensity of tuberculosis control efforts and greater reduction in tuberculosis prevalence supports a causal linkage between the two.

Finally, our results have implications for the present discussion about a new agenda for global tuberculosis control and elimination after the UN Millennium Development Goals expire in 2015.18–22 Of the new tuberculosis targets that will probably be considered by the World Health Assembly is a 50% reduction in tuberculosis incidence between 2015 and 2025. Achievement of such a target would be an important milestone toward tuberculosis elimination. Our results show the feasibility of such a target when a programme is put into place to substantially improve the quality of tuberculosis treatment. Countries can achieve this improvement with an aggressive scale-up of the DOTS programme if they have not done so already, but improvement of the treatment of patients diagnosed outside the DOTS programme, which is usually implemented only in the public sector, is essential. However, because many developing countries—including those with the highest tuberculosis burden—have already improved tuberculosis treatment in the past 10–15 years using the DOTS strategy, long-term, rapid reduction in the tuberculosis burden will need additional control efforts. These efforts include earlier detection and treatment of active tuberculosis and ultimately interventions and new instruments to reduce the risk of tuberculosis in the large global population with latent tuberculosis infection.

Contributors
YW, LW, HZ, YR, SC, MC, YZ, SJ, XD, GH, and DPC participated in the design and planning of the study. JL, SW, WC, CX, FH, and XL collected the data. LW, HZ, YR, YX, DPC, and YW did the data analysis and prepared the report for publication.

Declaration of interests
We declare that we have no competing interests.

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