Ifedayo MO Adetifa et al.

Tuberculosis prevalence in the Gambia

This online first version has been peer-reviewed, accepted and edited, but not formatted and finalized with corrections from authors and proofreaders.

A tuberculosis nationwide prevalence survey in the Gambia, 2012

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(Submitted: 16 December 2014 – Revised version received: 20 January 2016 – Accepted: 25 January 2016 – Published online: 21 April 2016)

Abstract

Objective To estimate the population prevalence of active pulmonary tuberculosis in the Gambia.

Methods Between December 2011 and January 2013, people aged ≥ 15 years participating in a nationwide, multistage cluster survey were screened for active pulmonary tuberculosis with chest radiography and for tuberculosis symptoms. For diagnostic confirmation, sputum samples were collected from those whose screening were positive and subjected to fluorescence microscopy and liquid tuberculosis cultures. Multiple imputation and inverse probability weighting were used to estimate tuberculosis prevalence.

Findings Of 100 678 people enumerated, 55 832 were eligible to participate and 43 100 (77.2%) of those participated. A majority of participants (42 942; 99.6%) were successfully screened for symptoms and by chest X-ray. Only 5948 (13.8%) were eligible for sputum examination, yielding 43 bacteriologically confirmed, 28 definite smear-positive and six probable smear-positive tuberculosis cases. Chest X-ray identified more tuberculosis cases (58/69) than did symptoms alone (43/71). The estimated prevalence of smear-positive and bacteriologically confirmed pulmonary tuberculosis were 90 (95% confidence interval, CI: 53–127) and 212 (95% CI: 152–272) per 100 000 population, respectively. Tuberculosis prevalence was higher in males (333; 95% CI: 233–433) and in the 35–54 year age group (355; 95% CI: 219–490).
Conclusion

The burden of tuberculosis remains high in the Gambia but lower than earlier estimates of 490 per 100 000 population in 2010. Less than half of all cases would have been identified based on smear microscopy results alone. Successful control efforts will require interventions targeting men, increased access to radiography and more accurate, rapid diagnostic tests.

Introduction

Tuberculosis killed 1.5 million people in 2014 and is the leading cause of death from an infectious disease worldwide.\textsuperscript{1} Sub-Saharan Africa, with 28% (9.6 million) of all notified tuberculosis cases in 2014, endures a disproportionate burden of the disease relative to its population. In the Gambia, the estimated incidence and prevalence of tuberculosis rose from 258 and 350 per 100 000 population respectively in 1990 to 284 and 490 per 100 000 in 2011.\textsuperscript{2} In addition, the tuberculosis case detection rate – that is, the ratio of the number of notified tuberculosis cases to the number of incident tuberculosis cases in a given year –remained low at 48% (95% confidence interval, CI: 40–58%).\textsuperscript{2} It is not clear if poor case detection is due to inequitable access to care or inadequate diagnosis of tuberculosis in urban or remote parts of the country.

Given the need for improved, evidence-based interventions in tuberculosis control in the Gambia, it is important to establish reliable baseline estimates of tuberculosis prevalence against which future control interventions can be assessed. This study therefore aimed to estimate the population prevalence of active pulmonary tuberculosis disease in the Gambia, in 2012 and to compare the case detection rate with global tuberculosis control targets.

Methods

Study design

We carried out nationwide, multistage cluster survey in 2011–2013. A sample size of 55 281 participants $\geq 15$ years old from 80 clusters was calculated assuming a prevalence of 292 sputum smear-positive cases per 100 000 population,\textsuperscript{3} 85% participation target, design effect of 1.51 and application of a finite population correction.\textsuperscript{4} A sample size with 80 clusters was expected to give around 20% precision and higher than 25% precision under the most plausible scenarios, and with an intracluster coefficient of variation of 0.5 the calculated design effect was 1.51.

Sampling to select survey areas was multistage and without any stratification. First, we allocated 80 survey enumeration areas by regions of the country in proportion to population size based on the national 2003 census (central statistics department, Government of the
Gambia). Following this allocation, the West Coast region with about 28.7% (389 274) of the population was to contribute 23 enumeration areas and the least populated Lower River region contributed four enumeration areas for 5.3% (72 184) of the population. This procedure was similar in outcome to the recommended sampling in proportion to population size. Then we randomly selected the survey enumeration areas (e.g. 23 for West Coast region) up to a total of 80 for the entire country. Each selected survey enumeration area was paired with between one and two adjacent enumeration areas in whole or part until an adult population of 500–700 was attained.

People eligible for participation were all those aged ≥ 15 years; permanent residents who spent at least one night in the household in the preceding 4 weeks; and visitors who had arrived in the household 4 weeks or more before.

**Study procedures**

Three teams – each consisting of a research clinician who led a team of 7 trained fieldworkers and a radiographer – performed the fieldwork from December 2011 to January 2013. Data collection in each cluster was done over a seven-day period. The field workers, in collaboration with community-selected liaisons, enumerated the population in each cluster 4–6 weeks before actual data collection. The field workers visited the enumerated households to obtain data on household composition and residency, and at the same time discussed the purpose of the survey. For families that were not at home, the team were informed at which time they could return to meet the household members. Community entry meetings with the local chief and other community leaders were also held to provide further information.

The field operation sites were selected based on input from community members to ensure that location was as central as possible to facilitate access by pedestrian travel. Project vehicles were available for eligible disabled participants to bring them to the site.

Screening of eligible participants followed the World Health Organization (WHO) recommended algorithm for tuberculosis prevalence surveys. At the field operation site, participants gave written informed consent before they were interviewed for tuberculosis symptoms (cough, weight loss, fever, drenching night sweats, chest pain, shortness of breath, loss of appetite and coughing up of blood). Then they had chest X-rays taken by a radiographer who used a mobile direct digital radiography machine. Chronic cough lasting two weeks or more is the cardinal symptom in the national tuberculosis guidelines. Participants who screened positive for symptoms and/or had X-ray suggestive of tuberculosis
were asked to submit two sputum specimens. All those unable to have chest X-rays were asked to submit two sputum samples whether they had symptoms or not. Participants submitted the sputum samples at the field site, with 30–45 minutes interval. Participants who were unable to submit samples on-site were given two prelabelled containers for collection early the following morning. All survey participants were given a token gift of laundry soap.

**Case ascertainment**

Survey clinicians were encouraged to over-interpret X-rays to increase the sensitivity of screening, as recommended. The radiology panel, which included those who trained the X-ray readers, reviewed all abnormal X-ray and 10% of normal films for quality assurance and definitions. The final radiological diagnosis was determined via consensus by a pulmonologist and radiologist.

Sputum specimens collected in the field were stored in temperature monitored cold box. If the samples could not be transported to the laboratory that day, the samples were stored at kept in a 4 °C fridge in the team’s camp. In general samples were transported every 48 hours after sputum collection to the main laboratory, the maximum delay in transportation was 72 hours. Sputum samples were processed at the tuberculosis diagnostic and research laboratory of the Medical Research Council Unit The Gambia. The laboratory holds good clinical laboratory practice accreditation and subscribes to an external quality assessment service. Sputum smears were examined using fluorescence microscopy. Cultures were performed using the BACTEC Mycobacterial Growth Indicator Tube (MGIT) system (Becton Dickinson, Franklin Lakes, United States of America). Standard laboratory procedures were followed for confirmation of growth in liquid culture including rapid species identification with an immunochromatographic assay (MGIT TBc Identification Test, Becton Dickinson, Franklin Lakes, USA). All acid-fast bacillus (AFB) isolates obtained from cultures were classified as either *Mycobacterium tuberculosis* or nontuberculous mycobacteria.

The final survey case classification, as defined in Box 1, was done by a central panel consisting of infectious diseases and chest physicians, epidemiologists, laboratory experts and tuberculosis programme representatives.

**Data analysis**

There was double entry of survey data in a MySQL version 5.6.19 (Oracle, Redwood Shores, USA) relational database. All data analyses were done using Stata version 12.1 (Stata Corp., College Station, USA). We tested for differences in proportions using two-sample tests of
equality of proportions, and conducted multiple imputation to correct for missing data.\textsuperscript{8,9} For prevalence estimates, we used three modelling approaches with robust standard errors, missing value imputation and inverse probability weighting applied.\textsuperscript{4,8} With multiple runs of chained imputation data sets, trends for the mean values of the four imputed variables (chest X-ray-positive, AFB-positive, culture-positive and bacteriologically confirmed tuberculosis) were obtained for all iterations. We derived subject-level missing values from the relevant combinations of the imputed variables and stratified all prevalence data by sex, age group and residence (rural/urban). Overall prevalence for all forms of tuberculosis – that is, pulmonary and extra-pulmonary – across all age groups were obtained by calculating pulmonary tuberculosis cases (all ages) as a weighted average of tuberculosis in survey participants and in children (obtained from routine reports, Gambian national leprosy and tuberculosis programme). The value obtained was then revised upwards by the proportion of all notified tuberculosis cases that were the extrapulmonary type. Incidence was calculated based on assumptions from a set of statistical distributions as described elsewhere.\textsuperscript{2}

**Ethics approval**
The study obtained ethics approval from the joint ethics committee of the Gambian Government and Medical Research Council. All tuberculosis patients identified during the survey were promptly referred to the nearest treatment centre for treatment at no cost and notified to the national tuberculosis programme.

**Results**

**Participants**
Enumeration yielded 100,678 people in 13,847 households across 80 clusters, of whom 55,832 (55.5\%) were eligible to participate in the survey. The enumerated population was representative of the Gambia’s population structure (2003 national census) by age and sex (Fig. 1). Of the 55,832 people invited, 43,100 (77.2\%) consented to participate. As shown in Fig. 2, there was a significantly higher proportion of female (84.9\%; 25,596/30,153) than male participants (68.2\%; 17,504/25,679; \(P < 0.0001\)). In addition, participation was higher in rural (82.3\%; 25,554/31,043) than urban (70.8\%; 17,546/24,789) clusters (\(P < 0.0001\)). Overall, participation was slightly less than the 85\% target due to lower participation in urban areas and among males. The median age of participants was 28 years (interquartile range: 20–41 years).
Suspected cases

All participants were successfully screened for symptoms and 42,942 (99.6%) by X-ray (Fig. 3); the majority of missing chest X-rays (145/158, 91.8%) were due to patient refusal or ill health, while the remaining (13/158, 8.2%) were due to technical problems.

Cough was reported by 4,802 (11.1%) participants. Of those participants knowing the duration of their cough, 962 (2.2%) had had a cough lasting ≥2 weeks, 2,979 (6.9%) had coughed for <1 week and 799 (1.9%) had coughed for 1–2 weeks. With respect to other symptoms in the guidelines, 6,637 (15.4%) participants reported fever, 6,551 (15.2%) chest pain, 1,595 (3.7%) night sweats, 2,672 (6.2%) shortness of breath, 3,620 (8.4%) anorexia and 8,448 (19.6%) weight loss. Using other symptom categories, 1,372 (3.2%) participants reported cough of <2 weeks plus two or more of the other symptoms, while 1,128 (2.6%) did not have a cough but had three or more other symptoms.

Based on field X-ray screening, 3,407 (7.9%) participants had chest abnormalities suggestive of tuberculosis.

A total of 5,948 (13.8%) participants were classified as tuberculosis suspects and were eligible for sputum examination; 2,447 were eligible by symptom screening only, 2,382 by chest X-ray screening only and 1,050 by both screening methods (Fig. 3).

Definite cases

Laboratory results were available for 5,519 participants with suspected tuberculosis. Overall, 77 participants with pulmonary tuberculosis were identified, 71 of which were bacteriologically confirmed. The expert panel categorized 28 participants’ diagnostic results as definite, smear-positive (smear-positive, culture-positive), 43 as definite, bacteriologically confirmed (smear-negative, culture-positive) and six as probable, smear-positive (smear-positive, culture-negative; Fig. 3). Of the samples that both were smear positive and culture positive; 34 samples were identified by culture as *M. tuberculosis* and 2 (5.6%) as nontuberculous mycobacteria.

If sputum smear microscopy had been done only in symptomatic people, diagnosis would have been made in 52.9% (18/34) of prevalent smear-positive cases, while chest X-ray abnormalities would have identified 94.1% (32/34). Among all participants with bacteriologically confirmed tuberculosis, symptoms alone identified significantly fewer cases than chest X-ray screening in the field, 60.6% (43/71) versus 84.1% (58/69; \( P < 0.01 \)), respectively. In addition, 25/77 patients (32.5%) reported cough for ≥2 weeks, 14 (18.2%) for
< 2 weeks with two or more symptoms, while 5 (6.5%) did not have a cough but had three other symptoms. In total, 24.7% (19/77) of the participants were identified having tuberculosis because the patient screened positive for additional symptoms.

Tuberculosis was identified predominantly among male participants (51; 66.2%). The 15–34, 35–54 and ≥ 55 year age groups had 37.7% (29), 39.0% (30) and 23.4% (18) of cases respectively. The numbers of tuberculosis cases were similar in urban (39) and rural (38) clusters.

Most identified participants with tuberculosis (94.8%; 73) were not on treatment at the time of the survey and were not official registered with the national tuberculosis programme. Thirty-eight patients had sought care on account of their symptoms; all 38 had visited health facilities and the great majority of them (31/38) had visited a public health facility.

**Prevalence**

There were missing data for smear, culture and symptom identification for 512 participants eligible for sputum examination; 24 of these had missing chest X-ray as well. Bacterial identification was a conditional imputation, conditioned on a positive culture. In addition, 134 subjects had only X-rays missing. In total, 646 subjects required imputation analysis.

For the adjusted prevalence estimates for smear-positive and bacteriologically confirmed pulmonary tuberculosis, the results from the three models were consistent and for models 2 and 3 were quite similar, especially for smear-positive tuberculosis (Table 1). Considering the larger differences for bacteriologically confirmed tuberculosis by residence and sex with model 3, the extrapolation by inverse probability weighting in this model appears to have adjusted for the lower participation in urban areas and by males. This result suggests that model 3 has the best fit for our data. Based on model 3 the estimated prevalence of smear-positive tuberculosis was 90 per 100,000 population (95% CI: 53–127) and for bacteriologically confirmed tuberculosis was 212 per 100,000 (95% CI: 152–272).

Prevalent smear-positive tuberculosis was 3.4-fold higher in male than female participants. Bacteriologically confirmed pulmonary tuberculosis was 2.4-fold higher than smear-positive tuberculosis and 2.4-fold higher in urban than rural areas (Table 1). Table 2 shows age- and sex-associated differences in the burden of smear and bacteriologically confirmed tuberculosis based on estimates from model 3.
**Adjusted prevalence**

We calculated the adjusted tuberculosis prevalence for all ages and all forms of tuberculosis, with the assumptions that children aged < 15 years were 45.9% of the total population, childhood tuberculosis and extrapulmonary tuberculosis were 10.5% and 6.7% of all total notifications, respectively. This produced a national prevalence for all age groups and all types of tuberculosis of 128 per 100,000 population (95% CI: 94–162). The updated incidence was 175 per 100,000 population (95% CI: 135–215) and the tuberculosis case notification rate was 130 per 100,000 population. Using routine country tuberculosis notification data, the smear positive tuberculosis prevalence, in the population aged < 15 years, was 3 per 100,000, the revised prevalence was 53 per 100,000.

**Performance appraisal**

Comparing the estimated case detection rates against global tuberculosis control targets showed that the Gambia achieved the 70% case detection target over the period 2009–2013, except for the year 2010 (64.9%; Table 3).

**Discussion**

The overall prevalence of bacteriologically confirmed and smear-positive pulmonary tuberculosis in the Gambia were 3.8- and 5.5-fold lower respectively than previously estimated in 2011. These results are similar to those reported from Ethiopia, where the overall burden of tuberculosis was much lower than previously thought. Results from other recently concluded surveys in Rwanda, the Sudan and Zimbabwe, are also expected to report lower than expected prevalence. However, recent surveys carried out in other parts of Africa (Ghana, Malawi, Nigeria, the United Republic of Tanzania and Zambia) revealed higher than expected tuberculosis prevalence. Many of the earlier estimates of tuberculosis burden were derived from mathematical models. Therefore tuberculosis burdens could have been over- or underestimated, as actual measurements now suggest. For the Gambia, it is unclear whether earlier figures were exaggerated or understated because of the varying pattern of survey results across Africa. This reinforces the need for reliable country-level measures of tuberculosis burden through surveys such as ours.

The majority of patients with tuberculosis identified in our study were unknown to the national tuberculosis control programme and were not on treatment. While passive case detection has well known limitations, our data expose the importance of missed diagnostic opportunities within the routine health care system. This is not surprising given the
weaknesses of health systems in low-and middle-income countries. While it remains unclear if active case-finding can interrupt tuberculosis transmission in the community through early diagnosis,\textsuperscript{14} strengthening of case-finding through re-training staff and interventions such as the Practical Approach to Lung Health are essential.\textsuperscript{15,16} Given that tuberculosis prevalence surveys are expensive undertakings (United States dollars 59 per participant in this survey), alternative approaches to active case-finding are required in resource-poor settings.

Tuberculosis was predominantly found in male participants in our study. The overall male-to-female ratio of 2.0:1 among participants identified with tuberculosis is within the range of ratios reported for Africa and all tuberculosis high-burden countries (0.5:1–3.0:1).\textsuperscript{2} However, this conceals the fact that the male-to-female ratio of 3.7:1 for smear-positive tuberculosis in this survey exceeds the figures of 1.9:1 and 1.5:1 reported for the 22 countries with high-tuberculosis burden and the WHO African Region, respectively. In addition, the male-to-female ratio of 2.2:1 for all participants with bacteriologically confirmed tuberculosis exceeds the 1.7:1 and 1.3:1 reported for the tuberculosis high-burden countries and Africa. This sex difference was consistent across the survey case definitions, despite the lower participation by eligible males.

The majority of identified persons with tuberculosis were in the economically productive 15–44-year age group and this is an important finding for the Gambia’s economic well-being. Our survey also showed that tuberculosis prevalence increased with age, and, although the estimates were less precise for the oldest age group, our data points to the need for further investigation of tuberculosis among elderly people in the Gambia. While the prevalence of smear-positive tuberculosis did not differ significantly by rural or urban area, urban participants were twice as likely to have bacteriologically confirmed tuberculosis. This suggests increased access to routine and improved tuberculosis diagnostic services especially TB cultures, and particularly in urban areas.

The finding that less than half of all people with tuberculosis would have been identified based on smear microscopy results alone highlights the limitation of this diagnostic approach. Furthermore, the additional number of participants with smear-positive samples identified on the basis of a positive chest X-ray highlights the limitation of a diagnostic algorithm based on a combination of symptoms and smear microscopy alone. Clearly, the use of X-ray in diagnostic algorithms would increase tuberculosis case notifications in the Gambia. Our results also demonstrate the added benefit of using additional symptom categories to complement the most common tuberculosis symptom of chronic cough. More
than half of participants with tuberculosis identified were smear-negative and culture-positive, indicating that additional diagnostic tools, e.g. rapid diagnostics tests and/or tuberculosis cultures, are needed for early diagnosis.

The clinical epidemiology of nontuberculous mycobacterial disease in most of sub-Saharan Africa and indeed many low and middle-income countries is not well described. In our survey, 5.6% of participants with smear-positive samples were confirmed by culture as due to nontuberculous mycobacteria, pointing to a risk of over-diagnosis of pulmonary tuberculosis under programmatic conditions and the consequent prescription of unnecessary tuberculosis therapy. This further highlights the limitations of smear microscopy as the single diagnostic modality for national tuberculosis programmes in low- and middle-income countries.

The tuberculosis case detection rate was around 70% for the 5 years preceding the survey. Considering the >85% treatment success already achieved, the Gambia appears to have achieved the DOTS strategy targets for case detection and treatment. In addition, it has achieved the millennium development goal 6c for tuberculosis – have halted by 2015 and begun to reverse the incidence of malaria and other major diseases by 2015 – and Stop TB Partnership target for halving tuberculosis prevalence, as tuberculosis prevalence has decreased from 350 per 100,000 population in 1990 to 128 per 100,000 in 2013. There have been substantial investments in tuberculosis control efforts in the Gambia, including expansion of access to diagnosis and treatment, and various schemes to provide support to patients, all complemented by advocacy, communication and social mobilization efforts. However, the contribution which the expanded DOTS programme made to the improved tuberculosis case detection and notification is unclear. While the DOTS strategy is credited for increasing tuberculosis detection and treatment success and in progress towards achieving global tuberculosis control targets, other authors argue that it only improves treatment success. The reduced burden of tuberculosis and the progress made via tuberculosis control efforts in the Gambia, support the continued deployment of existing tuberculosis control strategies. However, the results of this survey highlight some gaps that need attention. For example, it is important to elucidate the factors associated with relatively stable tuberculosis notification rates despite achievement of the case detection and treatment success targets in the DOTS strategy.

This survey had some limitations. There were fewer participants than the target sample size but this was mainly the result of lower participation among males than females. Although
robust statistical methods were applied to adjust for this, we might not have completely eliminated selection bias and/or the possibility that this survey underestimated the burden of tuberculosis in male participants. Despite the risk of reported sex differences being understated and the less precise estimates for some of the sub-group analyses, we believe the results here are valid because the observed sex differences are consistent with reports from other surveys and the literature. In addition, the survey was not designed to directly measure extrapulmonary or childhood tuberculosis. Although we did not offer voluntary testing and counselling for human immunodeficiency virus infection, such counselling is offered routinely to all newly diagnosed tuberculosis patients at tuberculosis treatment sites in the Gambia, and uptake among newly diagnosed persons with tuberculosis exceeds 75%.1,22

Acknowledgements
During the study Ifedayo MO Adetifa was employed by the Disease Control and Elimination Theme, Medical Research Council Unit, Banjul, Gambia. We thank members of the survey steering committee; members of the survey technical advisory groups, Marina Tadolini and Sian Floyd; Ministry of Health and Social Welfare, Gambia; ministers of health, Gambia; Adama Jallow, manager and team at the Gambian National Leprosy and Tuberculosis Programme; regional directors of health, Gambia; Medical Research Council Unit, Gambia, Tumani Corrah, Richard Adegbola; MRC Research Support Office, Dembo Kanteh, Joan Vivestomas, Elina Cole; other scientific officers and laboratory technologists, MRC Tuberculosis Research and Diagnostic Laboratory; WHO Tuberculosis Impact Measurement Taskforce, Geneva, especially Ikushi Onozaki and Babis Sismanidis; WHO representatives and offices, Ethiopia and Gambia.

Funding:
The Global Fund to Fight AIDS, Tuberculosis and Malaria financed this study with support from the Medical Research Council Unit, Gambia.

Competing interests:
None declared.
References


### Box 1. Case definitions for the national tuberculosis prevalence survey, the Gambia, 2012

**Laboratory case definitions**

- Culture-confirmed tuberculosis case: isolation of *Mycobacterium tuberculosis* complex from a sputum specimen.

- Sputum smear-positive tuberculosis case: acid-fast bacillus (AFB)-positive by sputum smear examination, i.e. at least one AFB in 100 immersion fields.

**Definite survey case**

- Bacteriologically confirmed tuberculosis case: one positive tuberculosis culture and at least one of the following:
  - another sample culture-positive;
  - sputum smear-positive; or
  - chest X-ray abnormalities suggestive of tuberculosis by central audited reading.

- Sputum smear-positive tuberculosis case: one AFB-positive sample and a culture-positive sample.

**Probable smear-positive tuberculosis case**

- An AFB-positive sample and at least one of the following:
  - AFB-positive in another sample but not culture-positive, and no isolation of nontuberculous mycobacteria; or
  - Chest X-ray abnormal at central reading but not culture-positive, and no isolation of nontuberculous mycobacteria.
Table 1. Adjusted overall estimated prevalence of pulmonary tuberculosis per 100 000 population aged ≥ 15 years, the Gambia, 2012

<table>
<thead>
<tr>
<th>Group</th>
<th>Smear-positive cases</th>
<th>Bacteriologically confirmed cases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Model 2&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Overall point estimate</td>
<td>80 (44–116)</td>
<td>92 (55–128)</td>
</tr>
<tr>
<td>Residence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>79 (27–132)</td>
<td>90 (44–142)</td>
</tr>
<tr>
<td>Urban</td>
<td>81 (35–127)</td>
<td>93 (44–142)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>40 (0–81)</td>
<td>40 (1–80)</td>
</tr>
<tr>
<td>Age group (years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15–34</td>
<td>45 (19–71)</td>
<td>53 (23–82)</td>
</tr>
<tr>
<td>≥ 55</td>
<td>146 (55–387)</td>
<td>187 (0–385)</td>
</tr>
</tbody>
</table>

Cl: confidence interval.

<sup>a</sup> Model 1: logistic regression model with robust standard errors and no missing value imputation.

<sup>b</sup> Model 2: logistic regression model with robust standard errors and missing value imputation of non-participants as well as participants.

<sup>c</sup> Model 3: logistic regression model with robust standard errors, with missing value imputation of participants with missing smear and/or culture results, and inverse probability weighting applied to all survey participants to correct for differentials in participation by age, sex and residence.\(^4,8\)
Table 2. **Prevalence of pulmonary tuberculosis by sex and age group per 100 000 population aged ≥15 years, the Gambia, 2012**

<table>
<thead>
<tr>
<th>Group</th>
<th>Prevalence per 100 000 population (95% CI)a</th>
<th>Smear-positive cases</th>
<th>Bacteriologically confirmed cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>15–34 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>104 (42–166)</td>
<td>209 (113–305)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>33 (0–78)</td>
<td>71 (20–191)</td>
<td></td>
</tr>
<tr>
<td>35–54 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>282 (118–445)</td>
<td>634 (384–885)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>26 (0–80)</td>
<td>105 (19–191)</td>
<td></td>
</tr>
<tr>
<td>≥55 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>83 (0–203)</td>
<td>325 (108–543)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>227 (0–557)</td>
<td>330 (0–677)</td>
<td></td>
</tr>
</tbody>
</table>

CI: confidence interval.

a Model 3: robust standard errors with missing value imputation and inverse probability weighting; confidence intervals were calculated with exact binomial probability theory.
Table 3. **Tuberculosis case detection rates in the Gambia in the years 2009–2012 based on revised tuberculosis incidence estimates**

<table>
<thead>
<tr>
<th>Group</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1 681 734</td>
<td>1 728 394</td>
<td>1 776 103</td>
<td>1 824 777</td>
<td>1 882 450</td>
</tr>
<tr>
<td>Total no. of all types of notified tuberculosis&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2 065</td>
<td>1 962</td>
<td>2 249</td>
<td>2 333</td>
<td>2 340</td>
</tr>
<tr>
<td>Total no. of estimated incident cases&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2 943</td>
<td>3 024</td>
<td>3 108</td>
<td>3 193</td>
<td>3 294</td>
</tr>
<tr>
<td>No. of notified cases per 100 000 population</td>
<td>123</td>
<td>114</td>
<td>127</td>
<td>128</td>
<td>124</td>
</tr>
<tr>
<td>Case detection rate, % (95% CI)</td>
<td>70.2 (68.5–71.8)</td>
<td>64.9 (63.1–66.6)</td>
<td>72.4 (70.7–73.9)</td>
<td>73.1 (71.5–74.6)</td>
<td>71.0 (69.5–72.6)</td>
</tr>
</tbody>
</table>

CI: confidence interval.

<sup>a</sup> Data source: 2013 census, central statistics department, Government of the Gambia; other years are estimated values.

<sup>b</sup> Data source: routine reports from Gambia national tuberculosis programme.

<sup>c</sup> Estimated incidence is 175 per 100 000 population.
Fig. 1. **Population pyramids showing representativeness of eligible populations in the national tuberculosis prevalence survey, the Gambia, 2012**

Note: Nationwide population was 1 306 681 and eligible population was 55 832 people.
Fig. 2. Population pyramids showing representativeness of study populations in the national tuberculosis prevalence survey, the Gambia, 2012

Note: Eligible population was 55,832 people and participant population was 43,100 people.
Fig. 3. **Outline of the national tuberculosis prevalence survey, the Gambia, 2012**

- **100,678 total people enumerated in census**
  - **55,832 (55.5%) people eligible for study**
  - **43,100 (77.2%) participants screened by any method**
  - **5,948 (13.8%) participants eligible for sputum collection**
  - **5,523 (92.9% of 5,948) participants submitted at least one sputum specimen**
  - **5,519 (99.9% of 5,523) participants with laboratory results available**
  - **77 Pulmonary tuberculosis cases identified**
  - **71 Bacteriological confirmed cases**
    - **28 Smear positive, culture-positive (36.4% of 77)**
    - **43 Smear-negative, culture-positive (55.8% of 77)**
  - **6 Probable cases**
    - **6 Smear-negative, culture-positive (7.8% of 77)**

**Ineligible for study:**
- 41,570 (41.3%) children
- 3,276 (3.3%) adult non-residents

**Non-participants:**
- 10,664 present, refused
- 2,068 not present

**Screening methods:**
- **43,100 (100%) people screened by symptoms only**
- **42,942 (99.6%) people screened by CXR only**
- **42,942 (99.6%) people screened by both methods**

**Additional data:**
- **5,523 (92.9% of 5,948) participants submitted at least one sputum specimen**
- **5,376 (97.4% of 5,519) people with at least two sputum smears examined**
- **5,398 (92.9% of 5,519) people with at least one sputum smear examined**
- **5,434 people with at least one culture performed**
- **5,376 (97.4% of 5,519) people with two smears and two culture results available**
- **2 cases of non-tuberculous mycobacteria (5.6% of all 36 smear-positive cases)**

**CXR:** chest X-ray.