Tuberculosis in Bissau: incidence and risk factors in an urban community in sub-Saharan Africa

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Background Despite the long history of tuberculosis (TB) research, population-based studies from developing countries are rare.

Methods In a prospective community study in Bissau, the capital of Guinea-Bissau, we assessed the impact of demographic, socioeconomic and cultural risk factors on active TB. A surveillance system in four districts of the capital identified 247 adult (≥15 years) cases of intrathoracic TB between May 1996 and June 1998. Risk factors were evaluated comparing cases with the 25 189 adults living in the area in May 1997.

Results The incidence of intrathoracic TB in the adult population was 471 per 100 000 person-years. Significant risk factors in a multivariate analysis were increasing age (P < 0.0001), male sex (odds ratio [OR] = 2.58, 95% CI: 1.85, 3.60), ethnic group other than the largest group (Pepel) (OR = 1.64, 95% CI: 1.20, 2.22), adult crowding (OR = 1.68, 95% CI: 1.18, 2.39 for ≥2 adults in household), and poor quality of housing (OR = 1.66, 95% CI: 1.24, 2.22). Household type was important: adults living alone or with adults of their own sex only, had a higher risk of developing TB than households with husband and wife present, the adjusted OR being 1.76 (95% CI: 1.11, 2.78) for male households and 3.80 (95% CI: 1.69, 8.56) for female households. In a multivariate analysis excluding household type, child crowding was a protective factor, the OR being 0.68 (95% CI: 0.51, 0.90) for households with ≥2 children per household.

Conclusions Bissau has a very high incidence of intrathoracic TB. Human immunodeficiency virus (HIV), increasing age, male sex, ethnicity, adult crowding, family structure, and poor housing conditions were independent risk factors for TB. Apart from HIV prevention, TB control programmes need to emphasize risk factors such as socioeconomic inequality, ethnic differences, crowding, and gender.

Keywords Tuberculosis, HIV infection, incidence, risk factor, sub-Saharan, Africa, community study

The human immunodeficiency virus (HIV) epidemic has aggravated an already severe tuberculosis (TB) situation leading to accelerating incidence figures worldwide.1 The WHO reports an 81% increase in notification rates for the African continent, from 58/100 000 in 1980 to 105/100 000 in 1999.2 In order to control TB in this situation it is crucial to fully understand the disease patterns. Surprisingly few community studies have been performed in developing countries to clarify how different factors interact in the development of active TB.3 The recent resurgence of interest in TB has mainly lead to an increase in studies of HIV and TB. Furthermore, studies from developing countries are rare.4

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countries have in several cases failed to find support for risk factors like age, socioeconomic conditions, and crowding which were thought to have played major roles during the TB epidemic in the industrialized countries. For example, studies from South Africa and Malawi have found no association between crowding, socioeconomic conditions, and TB.

Guinea-Bissau, a small country on the west African coast, is one of the poorest countries in the world with a high prevalence of HIV type 2 (HIV-2) infection (6.8% in 1996), an increasing prevalence of HIV-1 (0% in 1987 to 2.2% in 1996 in the capital), and an increasing national incidence of TB (76/100 000 in 1987 to 153/100 000 in 1996). Previous studies from Bissau have shown high prevalences of HIV among TB patients, 38.8% of patients being HIV-positive. In 1996, we implemented a TB surveillance system, with passive and active case finding, in four suburban areas of the capital city, Bissau. The population in the areas has been followed demographically through a census system for many years. The demographic, socioeconomic, and environmental background data allowed us to study risk factors for active TB both at a community and household level. We did not evaluate behavioural factors in the present study.

Materials and Methods

Population and TB surveillance

The study area consists of four suburban areas of Bissau, the capital of Guinea-Bissau. Bandim 1 has been under demographic surveillance since 1978, Bandim 2 and Belem since 1984, and Mindara since 1994. The population of around 43 000 is registered with information on sex, ethnic background, and dates of birth, death and migration. Several ethnic groups are represented in the area. Most groups are animistic, such as Pepel, Manjacos, Mancanhas and Balantas, but there are also Muslim groups such as Mandingas and Fulas living in the area (Table 2). A general census for all four areas was performed in 1995–1996 and the information is updated regularly through surveillance systems. On 6 May 1997, 25 189 adults and 17 948 children were living in the area. A general census for all four areas was performed in 1995–1996 and the information is updated regularly through surveillance systems. On 6 May 1997, 25 189 adults and 17 948 children were living in the area.

Beginning in May 1996, a TB surveillance programme based on passive and active case finding was implemented in collaboration with the national TB hospital (Hospital Raoul Follereau). The study ended on 6 June 1998, due to the outbreak of a civil war. All adult patients (≥15 years) permanently or temporally living in the study area presenting at any of the two health centres with symptoms or signs of active TB were referred to the hospital for further investigation. Two nurses performed active case finding; every third month they visited houses where cases had been found, examining and interviewing the household members in order to detect secondary cases. Suspect cases were referred to the TB hospital for further medical examination. Patients living permanently in the area, but with TB treatment initiated elsewhere during the study period, were also referred to the hospital for further investigation and possible inclusion in the study. The nurses distributing TB medicine at the local health centres identified such patients when they came to collect medicine within the national TB control programme.

Criteria for inclusion in the study was age ≥15 years and one or more of the following symptoms and signs without other explanatory disease; cough for more than one month without improvement after antibiotic treatment, fever constantly or periodically for more than one month, weight loss, dyspnoea, haemoptysis, nightly sweats, or lymphadenopathy. Patients were examined clinically, interviewed using standardized questionnaires, and direct microscopy of morning sputum was done on 3 consecutive days as well as sputum culture and tuberculin skin test (using Multitest®, Bio-Merieux, France). Frontal chest x-rays were performed and pathological findings in the chest, including pulmonary changes, pleuritis, and hilar lymph node enlargements, were regarded as intrathoracic manifestations. Blood was drawn for HIV testing. Suspected cases with one or more sputum smears positive at direct microscopy or positive in culture for Mycobacterium tuberculosis were regarded as tuberculosis. As recommended by the International Union Against Tuberculosis and Lung Disease, patients with clinical signs, symptoms, and X-ray changes compatible with active intrathoracic TB, but without positive bacteriological tests, were treated with antibiotics (co-trimoxazole or amoxicillin) and then re-evaluated clinically and with chest X-ray. If there was no improvement and suspicion remained, the patient was diagnosed as having presumed tuberculosis. Smear positive patients and patients with severe disease were offered hospitalization if beds were available. Seven people were diagnosed and treated for active intrathoracic TB twice during the period; only the first episode was included in the analyses.

To evaluate the completeness of the TB surveillance system, we identified all adults who had died in the area during the study period. Two Guinean physicians performed verbal autopsies for 511 adults and all participating physicians later reviewed the forms in order to decide whether the individual was likely to have died with TB. Among the 511 deceased adults there were 39 who had died with symptoms of active TB. Two of these 39 had not been detected by the TB surveillance system and had thus not been included in the study. The two potential cases were not included in the analyses of incidence and risk factors for TB.

Many people living in the interior of Guinea-Bissau come to the capital and stay temporarily with relatives or friends to use the health services that the city offers. Such ‘guests’ are not included in the demographic census files and these individuals were excluded from the analyses in the present paper.

Households and houses

A household was defined as one or several people living together recognizing a specific person as the head of household. For the risk factor analyses the households were classified in the following way: Type 1—Adult men (one or more) only; Type 2—Adult women (one or more) only; Type 3—A male head of household with at least one wife present and possibly children; Type 4—a male head of household without wife but with children or adult female(s) present; Type 5—a female head of household without husband but with children or adult male(s) in the household.

Houses in the study area are one-storey, individually built, rectangular constructions, usually with 4–8 rooms and are inhabited by 2–4 families (households). The majority of houses do not have an internal ceiling, leaving a gap between the walls and the roof, letting air flow between the households, thereby potentially permitting transmission of air-borne and vector-borne...
infections between members of different households. Walls and house foundations are made of dried mud-cement bricks or plain mud/earth. The floors are covered with cement, tiles, or dried mud. Internal walls are plastered with cement or mud. Roofs are covered with straw or corrugated iron. Some houses have an indoor kitchen and toilet, however most houses have latrines outside and preparation of food is performed on the veranda. We used information on the construction and quality of houses as an indicator of socioeconomic status. The following factors related to housing quality were used as indicators of poor living condition: no indoor bathroom, no indoor kitchen, mud floor instead of cement/tiles, straw roof instead of corrugated iron, poor quality of roof, poor quality of walls, house foundation made of mud/earth instead of bricks/cement, poor quality of foundation of house, and plastering of walls with mud instead of cement.

**Treatment**

A 4-month intensive phase of daily directly observed treatment with Ethambutol, Isoniazid (INH), Rifampicin, and Pyrazinamide was followed by a 4-month continuation phase with Isoniazid and Ethambutol collected at the health centre twice per month by the patient. This treatment regimen was recommended for HIV-infected individuals by the national TB programme in Guinea-Bissau when the research project was initiated in 1996. For reasons of confidentiality and comparability HIV-infected and uninfected individuals received the same treatment. In addition, all patients were given vitamin B complex and multivitamins daily. Adherence to treatment was verified by pill count by the nurses supplying medication and an INH urine test was performed at the hospital at 2, 5, and 8 months of follow-up. Defaulting patients were visited by the nurse and encouraged to continue treatment. Specific HIV drugs or prophylactic treatment for HIV-related diseases were not available in Guinea-Bissau.

**Laboratory methods**

A field assistant collected morning sputum samples during 3 consecutive days. The sputum samples were investigated by direct microscopy for presence of acid-fast bacilli and the most representative sample was cultured. No isolate was resistant to two or more drugs. Sera were screened for HIV at the National Health Laboratory of Guinea-Bissau (LNSP). Laboratory methods have previously been described more extensively.10,12

**Statistical analyses**

The census data as well as information from questionnaires and results of laboratory analyses were entered in databases using dBASE V software. Incidence and risk factors were estimated comparing cases included between 6 May 1996, and 6 June 1998, with the adult population (≥15 years) living in the area on 6 May 1997. Annual incidence figures were calculated based on the 25 months of surveillance and using the adult population (≥15 years) living in the area on 6 May 1997 as the mid-point or average population. Incidence figures are presented per 100 000. Test for trend was done using the extended Mantel-Haenszel $\chi^2$-test in Epi Info version 6.04.

Estimation of odds ratios (OR) for risk factors was calculated in logistic regression models using SAS for Windows version 8.2. Apart from the nine housing quality factors mentioned above, the following risk factors were evaluated in univariate analyses: sex, age group, ethnic group, residential area, family structure, adult (≥15 years) crowding, child crowding, and presence of a ceiling in the house. All factors, except housing quality factors not significant on a 5% level, were then fitted into a multivariate model.

A multivariate analysis was performed comparing TB cases positive in direct microscopy or culture with the adult population. Since risk factors for TB and HIV may not be independent, a multivariate analysis comparing HIV-negative TB cases with the adult population was performed. Furthermore, a similar sub-analysis was performed comparing HIV-positive TB cases with the adult population. Note that the comparison of HIV-positive TB cases with the population may express the risk factors for HIV infection rather than risk factors for TB. Factors significant to a 5% level in the multivariate analysis comparing all cases with the adult population were included in these three sub-analyses.

**Ethics**

Pre- and post-test counselling regarding both HIV infection and TB were available. The patients were informed in writing in Portuguese and verbally in the common language, Creol, before being enrolled in the study. The study was approved by the Ministry of Public Health in Guinea-Bissau, and by the Central Ethical Committee of Denmark.

**Results**

During the 25 months between May 1996 and June 1998, 247 new cases of intrathoracic TB occurred in the community (Figure). Of these, 132 were positive in direct microscopy of sputum (‘smear positive’) and/or had a positive culture of Mycobacterium tuberculosis. For 90 of the remaining 115 cases the diagnosis was based on clinical and radiological criteria. Twenty-five had initiated treatment elsewhere and were detected by our surveillance system when they came to collect medicine. Since they had already started treatment, reliable sputum was not possible to obtain. Information on HIV status was missing for three people who died before a test could be performed. Of the remaining 244 patients 14.8% (36/244) were HIV-1 positive, 15.6% (38/244) HIV-2 positive, 9.4% (23/244) were dual reactive (HIV-1 and HIV-2 positive), and 60.3% (147/244) were HIV-negative.

**Incidence**

On 6 May 1997, there were 25 189 adults, ≥15 years, living in the area. Hence, with 247 incident cases the annual incidence was 471 per 100 000 adults. In both males and females the incidence rates increased significantly with age also in the oldest group (Table 1). The incidence of smear positive cases increased with age, until the oldest age groups where it stabilised and then declined. The incidence among HIV-negative TB cases was stable between 15 and 44 years of age, and then increased considerably among older individuals (Table 1).

**Risk factors**

Table 2 compares risk factors in univariate and multivariate analyses for all cases, cases positive in direct microscopy and/or culture, and HIV-positive and negative cases with the general
population. Though not always significant due to smaller number of patients, the trends were essentially similar for all categories of TB cases.

Male sex and increasing age were significant risk factors for TB in both univariate and multivariate analyses. The largest ethnic group Pepel had considerably lower risk of TB compared with the other groups. In the multivariate analysis for HIV-negative cases, the Pepel ethnic group, which constitutes around 40% of the population in the study area, had significantly lower incidence compared with the other groups (OR = 0.64, 95% CI: 0.44, 0.94). The TB incidence did not differ between the districts in the study area. The number of households per house or the number of people, adults or children, living in the same house had no effect on the incidence of TB (not in Table). The presence of a ceiling had no impact on TB. All of the housing factors used as indicators of poor living conditions increased the risk of TB (Table 2). In the multivariate model, quality of house foundations remained significant.

In the multivariate analyses, adults living in a household with husband and wife present had the lowest risk of developing TB. The increased risk was most apparent in households with only male (household type 1) or female (household type 2) adults and no children. This was true also when restricting the analysis to HIV-negative cases. Crowding was calculated separately as ‘child crowding’ and ‘adult crowding’ (>2 children and >2 adults per household, respectively). Adult crowding was a risk factor for TB: in an analysis including all variables, each adult in the household increased the risk of TB by 5% (95% CI: 0, 10%) (Table 3). The household type classification essentially depicted a difference between households with and without children. If household type was not included in the multivariate model maintaining the other variables as in Table 2, increasing number of children decreased the risk for TB (Table 4), the OR being 0.68 (95% CI: 0.51, 0.90) for households with >2 children per household.

It should be noted that there was no difference in incidence for men and women living alone or with adults of their own sex (HH Type 1 and 2, Table 2), the male–female incident ratio being 1.05 (95% CI: 0.53, 2.10). Hence, the marked difference in the male–female incident ratio occurred only for adults living with children and/or adults of the opposite sex, the male–female incident ratio being 2.39 (95% CI: 1.78, 3.21) (test of interaction, \( P = 0.03 \)).

Discussion

The study design, with a population followed demographically for many years and with surveillance of all cases of adult intrathoracic TB, gave us a unique opportunity to study the incidence adjusted by age and potential risk factors in a community setting. The adult population studied had a high annual incidence of intrathoracic TB; 471 per 100 000. The incidence of smear positive TB was 177/100 000 (Table 1). However, for 25 of the patients it was not possible to obtain reliable sputum since they had started treatment prior to such evaluation. Given that 41.9% (93/222) of the patients with a valid sputum sample were smear-positive, the incidence of smear positive TB was 197 per 100 000. The incidences for the neighbouring countries Senegal and Guinea-Conakry were, in 1997, 94 and 59 per 100 000, respectively, including all forms of TB and also including the child population.
### Table 1: Incidence rates and incidence rate ratios by age group for all, smear-positive, and human immunodeficiency virus (HIV)-negative tuberculosis cases

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Adult population</th>
<th>Tuberculosis cases</th>
<th>Crude annual incidence per 100 000 (^a)</th>
<th>Incidence rate ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td>All</td>
<td>Males</td>
</tr>
<tr>
<td>All</td>
<td>15–24</td>
<td>4401</td>
<td>5662</td>
<td>10 063</td>
</tr>
<tr>
<td></td>
<td>25–34</td>
<td>3388</td>
<td>3705</td>
<td>7093</td>
</tr>
<tr>
<td></td>
<td>35–44</td>
<td>2095</td>
<td>2090</td>
<td>4185</td>
</tr>
<tr>
<td></td>
<td>45–54</td>
<td>993</td>
<td>1047</td>
<td>2040</td>
</tr>
<tr>
<td></td>
<td>55–</td>
<td>846</td>
<td>962</td>
<td>1808</td>
</tr>
<tr>
<td>Allb</td>
<td>11 723</td>
<td>13 466</td>
<td>25 189</td>
<td>166</td>
</tr>
</tbody>
</table>

χ² = 37.8  \(P < 0.001\)

χ² = 44.2  \(P < 0.001\)

χ² = 82.1  \(P < 0.001\)

χ² = 3.09  \(P = 0.079\)

χ² = 2.60  \(P = 0.107\)

χ² = 6.25  \(P = 0.012\)

χ² = 20.0  \(P < 0.001\)

χ² = 13.9  \(P < 0.001\)

χ² = 35.7  \(P < 0.001\)

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\(a\) Giving all individuals in the population a follow-up of 25 months.

\(b\) All age groups combined.
## Table 2 Risk factors for active intrathoracic tuberculosis

<table>
<thead>
<tr>
<th>Demographic data</th>
<th>Cases with positive bacteriological tests versus population</th>
<th>HIV(^a)-negative cases versus population</th>
<th>HIV-positive cases versus population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crude odds ratio (95% CI)</td>
<td>Adjusted odds ratio (95% CI)</td>
<td>Adjusted odds ratio (95% CI)</td>
</tr>
<tr>
<td></td>
<td>Adjusted odds ratio (95% CI)(^a)</td>
<td>Adjusted odds ratio (95% CI)(^c)</td>
<td>Adjusted odds ratio (95% CI)(^c)</td>
</tr>
<tr>
<td>All cases versus healthy population</td>
<td>Cases</td>
<td>Population</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>Male</td>
<td>166</td>
<td>11557</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>81</td>
<td>13385</td>
</tr>
<tr>
<td>Age group (years)</td>
<td>15–24</td>
<td>58</td>
<td>10005</td>
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<tr>
<td></td>
<td>25–34</td>
<td>51</td>
<td>7042</td>
</tr>
<tr>
<td></td>
<td>35–44</td>
<td>51</td>
<td>4134</td>
</tr>
<tr>
<td></td>
<td>45–54</td>
<td>44</td>
<td>1996</td>
</tr>
<tr>
<td></td>
<td>55+</td>
<td>43</td>
<td>1765</td>
</tr>
<tr>
<td>Ethnic group</td>
<td>Pepel</td>
<td>72</td>
<td>9773</td>
</tr>
<tr>
<td></td>
<td>Manjaco</td>
<td>39</td>
<td>4124</td>
</tr>
<tr>
<td></td>
<td>Mancanha</td>
<td>28</td>
<td>2745</td>
</tr>
<tr>
<td></td>
<td>Balanta</td>
<td>34</td>
<td>2236</td>
</tr>
<tr>
<td></td>
<td>Fula</td>
<td>26</td>
<td>1960</td>
</tr>
<tr>
<td></td>
<td>Mandinga</td>
<td>12</td>
<td>918</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>36</td>
<td>3186</td>
</tr>
<tr>
<td>Living area</td>
<td>Bandim 1</td>
<td>84</td>
<td>9927</td>
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<tr>
<td></td>
<td>Bandim 2</td>
<td>64</td>
<td>6074</td>
</tr>
<tr>
<td></td>
<td>Belem</td>
<td>60</td>
<td>5777</td>
</tr>
<tr>
<td></td>
<td>Mindara</td>
<td>39</td>
<td>3164</td>
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### Family and house characteristics

**Type of household**

<table>
<thead>
<tr>
<th></th>
<th>Households</th>
<th>Incidence</th>
<th>95% CI</th>
<th>OR (95% CI)</th>
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<tr>
<td>1</td>
<td>45</td>
<td>2417</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>564</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>121</td>
<td>14372</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>15</td>
<td>1052</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>56</td>
<td>6537</td>
<td></td>
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</tbody>
</table>

**Crowding, adults**

<table>
<thead>
<tr>
<th></th>
<th>Number of adults</th>
<th>Incidence</th>
<th>95% CI</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;2</td>
<td>168</td>
<td>17212</td>
<td>0.96 (0.73, 1.25)</td>
<td>1.68 (1.18, 2.39)</td>
</tr>
<tr>
<td>≤2</td>
<td>79</td>
<td>7730</td>
<td>1.00</td>
<td></td>
</tr>
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</table>

**Crowding, children**

<table>
<thead>
<tr>
<th></th>
<th>Number of children</th>
<th>Incidence</th>
<th>95% CI</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;2</td>
<td>97</td>
<td>12293</td>
<td>0.66 (0.52, 0.86)</td>
<td>0.78 (0.58, 1.07)</td>
</tr>
<tr>
<td>≤2</td>
<td>150</td>
<td>12649</td>
<td>1.00</td>
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</table>

**Presence of ceiling**

<table>
<thead>
<tr>
<th></th>
<th>Incidence</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>1.00 (0.66, 1.49)</td>
<td>1.04 (0.67, 1.62)</td>
</tr>
<tr>
<td>No</td>
<td>1.00</td>
<td></td>
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**Quality of foundation**

<table>
<thead>
<tr>
<th></th>
<th>Incidence</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor</td>
<td>1.60 (1.22, 2.11)</td>
<td>1.66 (1.24, 2.22)</td>
</tr>
<tr>
<td>Normal/good</td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>

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*In the univariate analyses we evaluated the following house quality variables which were not significant on a 5% level in a multivariate analysis, and were not included in the final models: no bathroom indoor (OR = 1.52, 95% CI: 1.02, 2.27); no kitchen indoor (OR = 1.30, 95% CI: 0.88, 1.89); mud floor instead of cement/tiles (OR = 1.52, 95% CI: 1.12, 2.05); straw roof instead of corrugated iron (OR = 1.51, 95% CI: 1.11, 2.06); poor quality of roof (OR = 1.68, 95% CI: 1.05, 2.69); poor quality of wall (OR = 1.36, 95% CI: 0.69, 2.65); house foundation made of mud/earth instead of bricks/cement (OR = 1.42, 95% CI: 1.10, 1.83); mud plastering of walls instead of cement (OR = 1.61, 95% CI: 1.25, 2.10).
incidence figures to smear-positive cases only, the incidence is
and treated intrathoracic TB. Also when restricting the
noted that cases, were diagnosed and treated against active TB,
‘over-diagnosed’ active intrathoracic TB. However, it should be
recorded in Mindara may have been more accurate.
areas followed for 15–20 years. The slightly higher incidence
estimated because of too many people on the census list in the
area most of the time but maintain a second residence elsewhere.
the demographic surveillance system. This could be the reason
why Mindara had slightly higher incidence than the three other
areas followed since the early 1980s (Table 2). Although the
census has been periodically updated in all areas, an old census
system may contain more relatives who are not really living in the
area. The TB surveillance system was initiated at the same time in
1996 and functioned in the same way in the four districts included
in the present study. However, the areas have been followed for
variable lengths of time, Mindara being included most recently in
the present study. We did not have the possibility of using
the household increased the risk for TB; adjusted odds ratio = 1.05 (95% CI: 1.00, 1.10).

<table>
<thead>
<tr>
<th>Adults in household</th>
<th>Tuberculosis cases</th>
<th>Population</th>
<th>Crude odds ratio (95% CI)</th>
<th>Adjusted* odds ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–2</td>
<td>79</td>
<td>7730</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>3–4</td>
<td>83</td>
<td>7724</td>
<td>1.05 (0.77, 1.43)</td>
<td>1.67 (1.15, 2.42)</td>
</tr>
<tr>
<td>5–8</td>
<td>63</td>
<td>6931</td>
<td>0.89 (0.64, 1.24)</td>
<td>1.68 (1.09, 2.57)</td>
</tr>
<tr>
<td>9–</td>
<td>22</td>
<td>2557</td>
<td>0.84 (0.52, 1.35)</td>
<td>1.86 (1.04, 3.31)</td>
</tr>
</tbody>
</table>

* Adjusted for sex, age, ethnic group, living area, type of household, child crowding, presence of ceiling, and quality of foundation. Each additional child in the household increased the risk for TB; adjusted odds ratio = 0.94 (95% CI: 0.89, 1.00).

The TB surveillance system was initiated at the same time in
1996 and functioned in the same way in the four districts included
in the present study. However, the areas have been followed for
variable lengths of time, Mindara being included most recently in
the demographic surveillance system. This could be the reason
why Mindara had slightly higher incidence than the three other
areas followed since the early 1980s (Table 2). Although the
census has been periodically updated in all areas, an old census
system may contain more relatives who are not really living in the
area. The result would be that the incidence was slightly under-
estimated because of too many people on the census list in the
areas followed for 15–20 years. The slightly higher incidence
recorded in Mindara may have been more accurate.

The inclusion of all suspected TB cases could be questioned
on the basis of diagnostic quality and it is possible that we have
‘over-diagnosed’ active intrathoracic TB. However, it should be
noted that cases, were diagnosed and treated against active TB,
and incidence figures thus reflect the incidence of diagnosed
and treated intrathoracic TB. Also when restricting the
incidence figures to smear-positive cases only, the incidence is
among the highest in the world.2 Almost 40% of our cases were
HIV-positive, which is a group well-known to be smear-
negative.15 It should be noted that our approach has not led us
to overestimate the effects of the risk factors. Misclassification
of cases would bias the OR towards 1.0 rather than produce false
risk factors.

It is noteworthy that the TB incidence rates showed a
significant increase with age, for both men and women (Table 1),
also in the oldest age groups. Official WHO figures2 only report
age-stratified notification rates for smear-positive cases, showing a decrease in incidence in the oldest age groups for
Africa. Our results are consistent with this pattern; the
incidence of smear-positive cases decrease in patients >55 years
(Table 1). This discrepancy between all and smear-positive cases
may be due to a tendency towards increased frequency of smear-
negativity with old age.15 For the HIV-negative individuals
there was a stable TB incidence up to age 44 and thereafter a
marked increase. Our incidence rates, increasing with age,
would correspond with data from the industrialized areas of
Europe in the beginning of the 20th century.5,16

TB is associated with poverty. TB is more common in poorer
countries2,14 but also within the individual countries, poorer
living areas have been associated with TB in both industrialized
countries4,17 and developing countries.18,19 Two studies from
sub-Saharan Africa, however, failed to show an association
between low socioeconomic level and active TB in adults.7,20 In
the present study, we did not have the possibility of using
income as a poverty factor and were restricted to secondary
indicators for housing quality, but poor living conditions was an
independent risk factor for active TB (Table 2). In our study
we found indications that the ethnic group Pepel was less
susceptible to TB, even when adjusting for socioeconomic
background factors (Table 2).

Recently, gender issues and TB control have generated much
interest. In most countries notification rates are higher for men
than for women,2 even in countries where equal access to

Table 3 Effect of adult crowding

<table>
<thead>
<tr>
<th>Adults in household</th>
<th>Tuberculosis cases</th>
<th>Population</th>
<th>Crude odds ratio (95% CI)</th>
<th>Adjusted* odds ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>73</td>
<td>4561</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>1–2</td>
<td>77</td>
<td>8088</td>
<td>0.60 (0.43, 0.82)</td>
<td>0.72 (0.50, 1.04)</td>
</tr>
<tr>
<td>3–4</td>
<td>55</td>
<td>6891</td>
<td>0.50 (0.35, 0.71)</td>
<td>0.57 (0.38, 0.86)</td>
</tr>
<tr>
<td>5–</td>
<td>42</td>
<td>5402</td>
<td>0.49 (0.33, 0.71)</td>
<td>0.51 (0.32, 0.80)</td>
</tr>
</tbody>
</table>

* Adjusted for sex, age, ethnic group, living area, adult crowding, presence of ceiling, and quality of foundation. Each additional adult in
the household increased the risk for TB; adjusted odds ratio = 1.05 (95% CI: 1.00, 1.10).

Table 4 Effect of child crowding

<table>
<thead>
<tr>
<th>Children in household</th>
<th>Tuberculosis cases</th>
<th>Population</th>
<th>Crude odds ratio (95% CI)</th>
<th>Adjusted* odds ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>73</td>
<td>4561</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>1–2</td>
<td>77</td>
<td>8088</td>
<td>0.60 (0.43, 0.82)</td>
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<td>3–4</td>
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</tbody>
</table>

* Adjusted for sex, age, ethnic group, living area, adult crowding, presence of ceiling, and quality of foundation. Each additional child in the household
decreased the risk for TB; adjusted odds ratio = 0.94 (95% CI: 0.89, 1.00).
health care for men and women is likely.2 Hence, it has been debated whether the difference is due to behavioural, socio-economic, or true biological effects, or a combination thereof,21 or due to TB being under-diagnosed or under-reported in women.22 In our study, we found that male sex was an important independent risk factor for TB (adjusted OR = 2.58, 95% CI: 1.85, 3.60), for all categories of patients (Table 2). The active case finding among contacts with TB cases and verbal autopsies should have minimized the problem of under-diagnosis for women. Furthermore, if males had been over-diagnosed this would have been most pronounced among cases diagnosed on clinical grounds. However, the male–female ratio in those diagnosed on clinical grounds (61/29 = 2.1) differed little from the ratio among patients with confirmed TB (86/46 = 1.9). Hence, it is highly unlikely that under-diagnosis in women or over-diagnosis in men can explain the observed sex difference in incidence.

Though the literature is conflicting on the role of crowding, our study does suggest that adult crowding is a risk factor for TB. Adult crowding was a significant independent risk factor also for HIV-positive individuals, which may be an indication that exogenous infection, as opposed to re-activation of disease, may be a contributor to active TB in these people. Children are less likely to be infectious and child crowding in the household should therefore have limited effect. The lack of adjustment for family structure and separation of crowding into adults and children may be reasons that other studies have failed to show crowding to be a risk factor.

An interesting finding in the present analysis was that family structure seemed to play a role. Previous studies have shown that marital status affects the risk of TB, with single men having a greater risk of TB than married men.24 In the present study we found that people living without children, alone or with adults of their own sex only, have higher risks of developing TB than people living in households with children or/and adults of the opposite sex. This finding remained significant for all categories of TB cases (Table 2). Restricting the analysis to adults living in families without children, adults in type 1 and 2 households had increased rates compared with household type 3, the adjusted OR being 1.60 (95% CI: 0.69, 3.73) and 4.98 (95% CI: 1.01, 24.8), respectively. The increased risk of adults living without children or individuals of the opposite sex may have to do with differences in lifestyles, but could possibly also be a result of some protection from contact with children since our analysis suggested that the protective effect increased with the number of children. Some protection from contact with children, possibly through immune stimulation from exposure to childhood infections, could be one of the reasons for the high TB incidence among young adults and old people, neither of whom would have much contact with young children. Since there was no difference in incidence for adult men and women living alone or with adults of their own sex, closer contact with children might also be one of the reasons that women have less TB than men.

Our census system did not contain complete information on smoking habits, alcohol abuse, nutritional status, schooling, presence of animals in the house, and working conditions. These factors, together with genetic differences or concomitant diseases in the individual, may play important roles in the development of TB and may explain some of our findings, such as the higher risk in certain ethnic groups, members of certain household types, and males. The interactions between such factors and the risk factors presented in this paper need further investigation.

TB research in the last decades has focused on co-infection with HIV. The present study represents one of very few community studies of non-HIV risk factors for active TB among adults in a sub-Saharan setting. We have shown that the risk factors for active TB in developing countries today are the same that physicians encountered in their daily work 100 years ago in Europe and North America. Age, sex, ethnic group, adult crowding, poverty, and family structure are still highly important factors for active TB even in the era of the HIV epidemic. It is of great importance that international organizations, as well as national TB control programmes, acknowledge that there are differences in impact of risk factors in different settings and measures to combat TB may need to be targeted for the specific populations. Poverty reduction is essential and governments need to adopt action plans in order to reduce the absolute poverty and crowding among the most vulnerable. Recognizing that there may be major ethnic differences in the incidence of TB might help to define important behavioural risk factors and to target interventions to those most in need. It would seem essential to explore why mothers have less TB. Integration of TB and HIV control programmes may be beneficial in terms of counselling, education, and reducing the stigmatization of both diseases, as well as for specific issues such as TB case finding and prophylactic TB treatment for HIV positives.

Acknowledgements

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This study would not have been possible without the dedicated work of the field assistants, laboratory technicians, nurses and physicians working daily with the problems concerning tuberculosis. Special thanks go to Mali Jalo.
KEY MESSAGES

- There have been very few community studies of the incidence of tuberculosis (TB) in low-income countries. We conducted a community study in Bissau, which has a very high incidence of intrathoracic TB in the adult population (471/100 000).

- Previous risk factor studies from low-income countries have suggested discontinuity with the risk factors emphasized during the TB epidemic in industrialized countries, for example, crowding and socioeconomic conditions not being important.

- In Bissau, risk factors included human immunodeficiency virus (HIV) infection, increasing age, male sex, ethnicity, crowding, family structure, and poor housing conditions; apart from HIV, these factors were similar to those emphasized during the height of the TB epidemic in industrialized countries.

- Lower female incidence was only found in families with children, the number of children being protective.

- TB control programmes need to design and evaluate preventive strategies according to the different risk factors in different settings.

References

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