Tuberculosis infection and disease among schoolchildren: the influence of the HIV epidemic and of other factors

J R Villalbí, H Galdós-Tangüís, J A Caylà, P Casañas, A Ferrer, M Nebot

Abstract

Background—The HIV/AIDS epidemic has caused an excess of tuberculosis cases in Spain and in other countries, but its impact on tuberculosis infection is less well understood. This study presents a massive screening undertaken to estimate the prevalence of tuberculous infection in a cohort of primary school entrants. The evolution of the risk of infection is studied by comparison with previous data in the same population.

Methods—Tuberculin skin test screening with 2TU of PPD RT 23 of first grade students in the primary schools of Barcelona, in the 1994–95 school year (cohort born in 1988). Information was also sought from families of unscreened children. Contacts of PPD+ children were traced to locate index cases. The results were also linked to the case registry of the tuberculosis control programme.

Results—The prevalence of tuberculin reactors free of BCG vaccination among the 11 080 schoolchildren screened belonging to the 1988 cohort was 0.76%. A 3% annual decline in the annual risk of infection is estimated by comparison with previous data. The identification of 24 cases with a previous history of tuberculosis disease and of 13 cases with active disease diagnosed after the screening was possible by the follow up of these tuberculin positive children and of the information provided by families of unscreened pupils. The screening detected 1.5 new cases of tuberculosis per 1000 tuberculin tests performed. Tuberculosis infection could be traced to HIV infected tuberculosis cases for at least 6% of the positive schoolchildren.

Conclusions—The decline of the annual risk of infection continues in Barcelona, although at a slower pace than before the HIV/AIDS epidemic, probably attributable to the influence of injecting drug users with smear positive tuberculosis and HIV/AIDS.

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The human immunodeficiency virus (HIV) infection has caused a clear excess of tuberculosis cases in Spain and in other countries. The evolution of tuberculosis infection is less well understood. Some authors believe that the decline in infection continues, as the excess cases linked to the HIV epidemic is caused by the expression of tuberculosis disease among people who were already infected by Mycobacterium tuberculosis years ago, among whom the acquired immunodeficiency explains the clinical disease. However, a proportion of these cases may be infective, and thus contribute to the dissemination of infection to new population groups. In Spain, the concentration of HIV infection among people who are injecting drug users, many of whom are relatively young and are household contacts of children, could promote this infection pathway. In this context, monitoring the evolution of infection and disease becomes crucial to understand current changes. This is why this study was undertaken, based on the tuberculin screening of schoolchildren in the months of January to May 1995, during the first year of mandatory schooling (first grade, when pupils are 6–7 years old).

Universal BCG vaccination was interrupted in Catalonia and in Barcelona from 1976, so that current schoolchildren are free of BCG interference when submitted to the tuberculin test, except for a few born in other areas where BCG is used. Universal screening in first grade was interrupted in Barcelona in 1989 and universal screening in first graders was done in 1992. Its results suggested that infection prevalence kept declining, but at a slower pace than previously estimated. The comparison with previous studies was obscured by changes in tuberculin supply, as the Comité d’Experts en Tuberculose (Catalan Expert Committee on Tuberculosis) recommended in 1989 the use of 2 TU of PPD RT 23 instead of the 5 TU previously used.

This paper reports the results of a second universal screening with 2 TU of PPD RT 23, performed three years later, whose objectives are to assess the evolution of tuberculosis infection, and to clarify the status of those children not tested because parents explicitly denied permission for the test. The contribution of school-based screening to the identification and control of sources of infection is also evaluated, after a tuberculosis control programme has been in operation for 10 years.

Methods

Tuberculin skin tests were performed with 2 TU of PPD RT 23, in 0.1 ml of liquid solution and stabilised with Tween 80, in accordance
with the recommendations of the Departament de Sanitat i Seguretat Social (DSSS, the Health Department of the Catalan Government), and the National Consensus on Tuberculosis of Spain.910 As in the 1991–92 survey, tests were performed according to Mantoux procedure by nurses from the municipal school health teams, who had been previously trained to reach standardisation in skin test placement and reading, and who had wide experience in this task. Readings were made 72 hours after injection, and a test was considered to be positive when an induration with a diameter of 5 mm or more was measured, following the current guidelines, defined according to the low prevalence of atypical mycobacteria in Barcelona.9–12

Families of first grade pupils were informed before the test administration, and information was sought on previous tuberculin tests, as well as on place of birth and BCG vaccination, for those children not born in Catalonia. Rosters of all first graders, including date and place of birth, were kept. Children with a positive test were referred to the clinics of the Tuberculosis Prevention and Control Program of the DSSS. Those children testing positive who failed to attend the clinic were followed up to ascertain the causes. Thus, PPD+ children were classified according to the reason for testing positive: current or former cases of tuberculosis, infected without tuberculous disease, or BCG reactors free of tuberculosis. The nominal register of cases managed by the Division of Epidemiology of the Municipal Institute of Health was linked with the list of PPD+ children, to find out the cases of tuberculosis in the 1988 cohort who had been reported before the screening.13

Most schoolchildren screened were six years old at the time of the screening, but some were seven or even older. In fact, according to the existing regulations, children beginning first grade in 1994–95 are those children born in 1988, who must be six years old in 1995. As the screening was undertaken between January and May 1995, some of them were already seven years old when tested. Because some repeatees are included in first grade, only data from the 1988 birth cohort are included.

Annual risk of infection (ARI) is estimated by \(1-(1-P)^{\frac{1}{\text{age}}}.1415\) Results are shown by school district, and compared with information available from previous years. The \(\chi^2\) test was used to compare proportions.

### Results

The screening was offered to all schools in the city, and 379 schools, with 99.7% of all first graders, participated. In the 1988 cohort, 11 200 tests were made, and 11 080 read, with 90 testing positive. All were referred to the Tuberculosis Prevention and Control Program Clinics, where six of them, who were found to have been born outside Catalonia and to be BCG vaccine recipients were eventually considered to be vaccine reactors free of tuberculosis. Thus, there were 84 positive tests, with an

<table>
<thead>
<tr>
<th>District</th>
<th>PPD+</th>
<th>Schoolchildren screened</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ciutat Vella</td>
<td>10</td>
<td>469</td>
<td>2.13</td>
</tr>
<tr>
<td>Eixample</td>
<td>12</td>
<td>1461</td>
<td>0.82</td>
</tr>
<tr>
<td>Sants</td>
<td>7</td>
<td>1026</td>
<td>0.68</td>
</tr>
<tr>
<td>Les Corts</td>
<td>1</td>
<td>714</td>
<td>0.14</td>
</tr>
<tr>
<td>Sarria-Sant Gervasi</td>
<td>12</td>
<td>2037</td>
<td>0.59</td>
</tr>
<tr>
<td>Gracia</td>
<td>7</td>
<td>734</td>
<td>0.95</td>
</tr>
<tr>
<td>Horta-Guinardo</td>
<td>13</td>
<td>1348</td>
<td>0.96</td>
</tr>
<tr>
<td>Nou Barris</td>
<td>8</td>
<td>944</td>
<td>0.84</td>
</tr>
<tr>
<td>Sant Andreu</td>
<td>6</td>
<td>988</td>
<td>0.61</td>
</tr>
<tr>
<td>Sant Marti</td>
<td>8</td>
<td>1362</td>
<td>0.58</td>
</tr>
<tr>
<td>Total Barcelona</td>
<td>84</td>
<td>11074</td>
<td>0.76</td>
</tr>
</tbody>
</table>

Figure 1 Proportion of tuberculin reactors among first grade schoolchildren by birth cohort. Barcelona, 1985–86 to 1994–95.
estimated prevalence of 0.76%. The ARI estimate for 1994–95 is 0.10%. Table 1 presents the prevalence of PPD+ by school district. It fluctuates between 2.13% in the inner city Ciutat Vella district and 0.14% in Les Corts. Among the 10 PPD+ in Ciutat Vella, three were children from immigrant families from developing countries.

The results of tuberculin screenings in first grade, which were done with similar methods in the Barcelona schools over a decade, between 1985–86 (cohort born in 1979) and 1994–95 (cohort born in 1988) are shown in figure 1. However, until 1989–90 the DSSS supplied 5TU PPD RT-23, and 2TU PPD RT-23 was supplied afterwards. The annual mean decline of the ARI is 3% by comparison of the 1994–95 estimate with the previous estimate of 0.12% in 1991–92.

In this survey, systematic information on previous tests was sought from families. The families of 204 children whose parents denied consent for PPD testing, provided written information, and a positive result was reported for 43. If these data are combined with the screening results, the frequency of infection would be 127 among the 11 404 first graders for whom some information is available (1.11%). Then the ARI would be estimated at 0.16, a figure that is not comparable to previous data, which were derived from the results of the direct reading of PPD tests.

The follow up of the 127 PPD+ (84 found by screening and 43 reported by families, but not screened) confirmed the presence of 68 children with infection but free from tuberculous disease, 24 children with a previous history of tuberculosis, and of 13 cases of active disease diagnosed after the screening. Despite several attempts, the families of 22 children with a positive test could not be located for follow up. Through the linkage of this information with the nominal case registry, it was found that among the 24 children with a history of tuberculosis, 23 had been already reported to the case registry (95.8% completeness in...
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cases of tuberculosis or only infected with
Among the 149 children who had either been
33 children whose contacts could be studied,
history of intravenous drug use (18.2% of the
infected by a smear positive and HIV+ brother
among first graders were related to a single
source of infection could be found, six were
related with HIV infected patients. Four cases
among first graders were related to a single
index case, a smear positive and HIV− teacher,
infected by a smear positive and HIV+ brother
with a history of intravenous drug use. Thus,
six children with the disease may be traced to
smear positive HIV+ cases, all of them with a
history of intravenous drug use (18.2% of the
33 children whose contacts could be studied,
and 10.2% of the 59 children with the disease).
Among the 149 children there is be either
cases of tuberculosis or only infected with \(M\)
tuberculosis, a source of infection related to HIV
could be found for nine (6%).

The screening of 11 080 first graders re-
sulted in the finding of 13 new cases among
children, and four new cases among adults,
who were index cases. Thus the yield of the
screening was the detection and treatment of
1.5 previously unknown cases per 1000 tests
(besides the chemoprophylaxis among children
infected and free of disease).

Discussion
The comparability of these results with those of
previous surveys may be considered. As the city
population is rather stable, the proportion of
unscreened children is similar in different sur-
veys: in 1988 there were 13 556 births from
city residents, and in 1994–95 there were
11 080 tests among this cohort (81.7%); in the
1991–92 survey, 12 007 tests were done in the
1985 cohort, which had numbered 15 190
births (79%). The reporting of previous tubercu-
lin tests by families does not decrease screening
coverage. On the contrary, it provides information on a fraction of the unscreened children, which sheds new light on those not covered by the screening, suggesting that many of them have been in contact with \(M\) tuberculosis. Although the accuracy of parental reporting has not been ascertained, this finding is relevant for the interpretation of screening sur-
veys, and points to the small unscreened fraction as crucial in the understanding of the results. Although any estimate of the current situation must take into account the infor-
mation reported by families, to maintain the
internal validity of infection decline estimates,
only data derived from the PPD tests actually
performed during the survey should be used, to
preserve comparability, as information re-
ported by families on unscreened children was
not available for previous surveys.

The comparison of these results with those of
other studies in Spain raises methodological
issues. In recent years, screenings using similar
methods have been conducted in the Region of
Murcia, and the estimated prevalence has been
slightly lower than in Barcelona, which is
understandable as infection prevalence is
higher in the pockets of marginality found in
large cities.\(^1\)\(^2\)\(^3\) The comparison of these results with
those in the Region of Madrid would be
most interesting: a recent survey in Madrid
found 0.3% of PPD+.\(^4\)\(^5\) Unfortunately, the
comparison is not appropriate, because the
sampling method in the Madrid Region (a
stratified sampling with three strata and a sam-
ping fraction of 4.4%) is very likely to under-
estimate prevalence for a low frequency event
with a frequently aggregate occurrence such as
tuberculosis infection. In Barcelona, if the
three schools with more than two positive tests
(all of which were in the inner city) had not
been screened, the estimated prevalence would
have been 12% lower. The probability that one
of these schools would be included in a sample
such as in the Madrid screening is lower than
0.02. Besides, there is no information for
unscreened children in Madrid. Thus, com-
parisons with the Madrid Region prevalence
should not be undertaken.

The 22 reported cases in the nominal case
registry that were not found by the screening,
point to the fact that the unscreened children
differ from the screened. Although some of
these children may belong to families who have
moved from the city, most probably they were
either absent from schools on screening days,
or their families refused the tuberculin test and
did not report the history. Perhaps they fear
negative social reactions in the school setting
because of tuberculosis. If we accept these
cases as city residents and add them to the
screening results, we could estimate 59 cases
over the first seven years of age for the 13 556
children born in 1988: an annual incidence rate
of 62.2 cases per 100 000 person years, which
seems rather high for our social context. These
figures may be overestimates because of two
reasons. In the first place, because they include
selective information from unscreened subjects
who enter the denominator only because they
enter the numerator. In the second place,
because some PPD+ may be false positives
because of atypical mycobacteria.

They are likely to be among those PPD+ for whom no
index case was found. We have found more
index cases among contacts of cases than among
contacts of PPD+, although it may be that the contact tracing effort is more intense
for a clinical disease case than for a positive
chemoprophylactic test. If close contact with a smear
positive case is more likely to result in tubercu-
losis disease than in just infection, contact
tracing is more likely to identify sources of
infection that resulted in new cases. The stud-
ies on atypical mycobacteria conducted in Bar-
celona 15 years ago,\(^6\)\(^7\) which established a low
prevalence of atypical mycobacteria, should be

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repeated, as its ecology may have changed in the meantime.

As this study shows, it is difficult to have an accurate estimate of infection prevalence in a community. For most populations, comprehensive data linking cross sectional surveys and case registries are not available. The 1.32% prevalence, estimated by combining survey data and the registry information, almost doubles the 0.76% prevalence estimated from the direct PPD test results. It reflects the current situation in the city, where a comprehensive control programme has now been in operation for 10 years, and questions survey results from areas without a surveillance programme and that ignore the unscreened population. Recently, studies based on active surveillance methods have estimated incidence rates similar or higher than in Barcelona for other areas in Spain for which case rates previously derived from routine reporting were low.19 20

These results strongly suggest that the decline of tuberculosis infection in the city of Barcelona continues, although at a slower pace than estimated before the HIV epidemic.5 6 Thus, despite the relatively high AIDS incidence rates and the associated increase in reported cases of tuberculosis from 1989 to 1991,11 tuberculosis infection among children has not increased. This conclusion is relevant for Barcelona, for Spain, and for other countries with a similar epidemiological pattern. The change from 5TU to 2TU in the PPD test made the comparison of the 1992 survey results with previous surveys problematic, but now this conclusion may be reached despite some limitations of this study, as both the 1992 and 1995 surveys have been based in 2TU. In fact, we may have overestimated the ARI because of the increasing number of children from families immigrating from developing countries, as their rates of infection may reflect the risk in their country of origin rather than the risk in the city.21 22 While some are born in Spain, others were born in other countries and immigrated later on: in the early 90s, about 2% of all live births are to mothers born in a developing country. It is hard to disentangle their influence in more depth. Analysis by place of birth or guessing ethnicity from children’s names has limited validity, and the routine collection of information on race or ethnicity in vital and census statistics is currently not considered acceptable in Spain.

The screening was undertaken to better understand the current epidemiology of tuberculosis infection. However, it has also resulted in the early detection of both cases and infected schoolchildren from the 1988 cohort, and thus chemotherapies and chemoprophylaxis should decrease the risk of disease incidence in this cohort. Because of this screening, several index cases previously unknown have been detected. Its yield is higher in our context than in other settings,24 and it should not be overlooked, especially in deprived areas. This strategy was already being used in those neighbourhoods considered to be at higher risk, and this should result in a decrease in the future disease incidence among the screened cohorts. In fact, there has been a decrease in the rates among children and teenagers in Barcelona over the past years, while incidence rates in young adults increased.

We may infer from these results that a smear positive and HIV infected patient was the source of infection for at least 6% of all children with infection. This confirms the potential of the tuberculosis-HIV coinfecion to influence the epidemiology of tuberculosis. However, this figure must be put in context: according to the Barcelona case registry, 28% of all new tuberculosis cases are infected by the HIV.13 The epidemiology of HIV in Barcelona shows that it is strongly related to intravenous drug use, which is more frequent in the most deprived areas of the city: this has resulted in a high frequency of HIV infection in those population groups who already suffered traditionally from high rates of tuberculosis infection. The epidemiology of HIV/AIDS in Spain may be defined by this pattern: some population segments with historically high rates of tuberculosis infection have also suffered heavily from HIV infection. This has resulted in higher rates of tuberculosis disease because of the immunity suppression caused by HIV, and also in high rates of AIDS, because of the impact of tuberculosis as an AIDS indicator disease. This pattern may also be true in other countries of southern Europe: high AIDS incidence rates linked to intravenous drug use and relatively high tuberculosis infection rates in childhood until two decades ago, result in high coinfecion for young adults, especially among some population groups.

Tuberculosis control must now face new challenges. The prevention of new infections remains the key issue: from a public health perspective, the main priority is still the early detection and proper treatment of tuberculosis cases, specially of smear positive cases.25 26

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**KEY POINTS**

- Tuberculosis infection among children keeps declining in an urban population with an organised tuberculosis control programme despite the resurgence of tuberculosis reports associated with the HIV/AIDS epidemic.
- When conducting a large scale tuberculin survey in schools, attention should be paid to the fact that many children with a history of tuberculosis or with a previously known infection are likely to be among the non-participants.
- In one of the urban areas with higher AIDS incidence in southern Europe, tuberculosis infection could be traced to HIV infected tuberculosis cases for at least 6% of PPD+ children.
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