Tuberculosis burden in Vietnam: What have we gained from the first national prevalence survey?

Nguyen, B.H.

Publication date
2013

Citation for published version (APA):

General rights
It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

Disclaimer/Complaints regulations
If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: https://uba.uva.nl/en/contact, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.
CHAPTER 7

First national tuberculin survey in Vietnam: characteristics and association with tuberculosis prevalence

NB Hoa¹, FGJ Cobelens², DN Sy³, NV Nhung¹, MW Borgdorff³, EW Tiemersma²,⁴

1. National Tuberculosis Programme, Hanoi, Viet Nam.
2. Institute of Global Health and Development, Academic Medical Center, Amsterdam.

Accepted for publication in the
International Journal of Tuberculosis and Lung Disease
Abstract

Objectives: To estimate the prevalence of infection with *Mycobacterium tuberculosis* and the annual risk of infection (ARTI) and to compare with the prevalence of tuberculosis over study clusters and households.

Methods: A nation-wide, stratified, cluster sample survey was carried out in 2006-2007 in Vietnam to assess the prevalence of infection with *M. tuberculosis*. A representative sample of children aged 6-14 years was tuberculin skin tested (TST) using the Mantoux method.

Results: Of 23,160 children registered, 21,487 (92.8%) were tested and read and available for analysis. Using a cut-off point of 10 mm, the estimated prevalence of TST positive was 16.7%, and the ARTI was 1.7% (95% CI: 1.5-1.8%). Higher infection rates were found in urban than in rural and remote areas, and infection rates increased with age. There was significant association between the prevalence of tuberculosis disease and infection at the cluster level (regression coefficient 0.54, 95% CI: 0.06-1.01, p=0.027, correlation coefficient R² 0.120). Children with a (recent) case of tuberculosis in the household were 1.6 times more likely to be TST positive than children in households with no recent cases (p<0.05).

Conclusion: The nationwide ARTI estimate was 1.7%. TST positivity was associated with presence of a TB case in the household.

Keywords Vietnam, Tuberculosis, Tuberculin, survey, prevalence, risk of infection
Chapter 7

Introduction

Tuberculosis control activities in Vietnam started in 1957, and the Vietnam National Tuberculosis Control Program (NTP) is based on the principles of the DOTS strategy recommended by the World Health Organization (WHO). The annual risk of tuberculous infection (ARTI) measures the extent to which transmission of Mycobacterium tuberculosis has occurred in the recent past in the community. The ARTI is calculated from tuberculin surveys. Even though direct estimation of the incidence rate from the ARTI is problematic, the trend in ARTI may reflect the trend in TB transmission and thus TB prevalence.

In Vietnam, from 1986 onwards, several local and regional tuberculin surveys were done. Although these tuberculin surveys provided useful information about trends in TB transmission, these surveys were not nationally representative, were carried out in small geographic areas with different BCG vaccination coverage rates, included pupils aged 6-8 years in selected schools only, and used different tuberculin.

In 2006-2007, the Vietnam NTP implemented a combined TB prevalence and tuberculin survey aimed at providing the Vietnam NTP with information on the size of the TB problem in order to assist the planning of TB control. This paper aims to estimate the prevalence of infection with M. tuberculosis and ARTI in a nationally representative sample of children and to compare the prevalence of infection to the prevalence of TB at household and district level.

Methods

Study setting and population

We conducted a population-based, cross-sectional TB prevalence survey, combined with a tuberculin survey, from September 2006 to July 2007, including 94,179 adults (15 years or older) and 23,160 children aged 6 to 14 years old. Seventy clusters were selected proportional to the population size as recorded in 1999, stratified by urban, rural and remote areas. Details about the design of the prevalence survey were reported previously. All children aged between 6 to 14 years in the same 70 clusters were included in the survey for tuberculin skin testing (TST).

Survey procedures

In each cluster, during the first two days, a census was done and the census register was completed for all registered children between 6 and 14 years old, including their school and class. For each class in each school in the community that had children included in the census register, a list of children occurring in the census register was prepared. TST administration and reading were done for children in this list. Children who did not attend school or a school outside the commune were invited to come to the community health post for testing and reading on selected days.
Tuberculin skin test
Tuberculin testing was performed by trained health survey teams, following the international guidelines using two tuberculin units (TU) of purified protein derivative (PPD) RT23 with Tween 80 (State Serum Institute, Copenhagen, Denmark). Children with skin rash on both forearms, fever, those on anti-tuberculosis treatment or whose parents/guardians did not agree to test were excluded. First, BCG status was recorded as the presence of a typical scar. The test was then administered in the dorsal left forearm with 0.1 ml of PPD RT23/Tween 80 containing 2 TU and the diameter of the reaction was measured with a transparent ruler after 72 hours (3 days) by trained survey teams.

Data management and analysis
All data were double-entered in EpiData; discrepancies were checked against the raw data. Data analysis was performed using Stata v10SE (Stata Corporation, College Station Texas, USA).

A positive TST was defined as duration of ≥ 10 mm. We estimated the ARTI among children with stratification by BCG status, sex, age, area, zone and socio economic status (SES). The ARTI was calculated as ARTI = 1 - (1 - P) 1/ā, where P is the prevalence of infection, and ā is the mean age at last birthday plus 0.5 years of the study group. We investigated factors associated with prevalence of infection by univariate and multivariate logistic regression analysis, and assessed the univariate association between positive TST and presence of TB cases in the household. We analyzed the association between prevalence of TST positive and the prevalence of TB disease by plotting them at cluster level and by linear regression taking, per district, the prevalence of TB disease as outcome variable and the prevalence of TST positive as independent variable, controlling for potential confounders and stratifying by relevant variables, such as geographical zone, urban, and SES.

The cut-off level of 10 mm used for defining infection prevalence may provide incomplete specificity for latent TB infection and thereby biased estimates for the associations. We therefore repeated the analyses using a cut-off level of 17 mm, which is considered to have higher specificity. In all analyses, population weights were applied to adjust for the stratified sampling design, for differences between clusters in population growth since 1999, and for differential cluster size. The prevalence of infection estimates and 95% confidence intervals were calculated using the Stata “svy” commands.

Presence of TB disease within households was defined as ‘current’ if it contained a patient detected by the survey, (both smear positive and culture positive), as ‘recent’ if at least one of the household members reported having been treated for TB in the 2 years preceding the survey, or as ‘no disease’ otherwise.

Ethical approval
The Research Board of the National Hospital for Tuberculosis and Respiratory Diseases in Hanoi gave scientific and ethical clearance to implement the study. During the census of the survey (one to three days before testing), parents were informed about the purpose of the survey by the survey field team including the risks and the benefits of the study. It was clearly explained that they had all rights to refuse participation and that they could withdraw at any
Chapter 7

85

point in time. Pamphlets containing information on the purpose of the survey, characteristics of
the TST test, the right to refuse, dates of testing and reading were also provided to
parents/guardians of the children. All parents were subsequently asked for informed consent.

Results

A total of 23,160 children aged 6-14 years were
included in the census register. Of these,
22,585 children (98.7%) were present at the tes-
ing day and 22,427 (96.8%) were injected with
tuberculin. Reaction sizes were measured for 21,487 children (92.8%). The mean duration from
injecting to reading was 2.94 days (95% CI: 2.93-2.95 days). (Figure 1)
These children were included in the data analyses, unless specified differently. The mean age
was 10.8 years (SD=0.02). Of the 21,085 children (98.1%) checked for presence of a BCG scar,
17,757 (84.2%) had a BCG scar.
Frequency distributions of reaction size among all children by zone (North, Central and South
of Viet Nam), stratified for BCG status, are presented in figure 2.
Using a cut-off point of 10 mm, the estimated prevalence of TST positive was 16.7 % (95%CI:
15.2-18.2%). The prevalence of TST positive was lower in the group without BCG scar
(13.1%) than in the group with BCG scar (17.2%), (OR=0.69; 95% CI:0.62-0.77); and lower in
girls (15.9%) than in boys (17.4%), (OR=0.89; 95% CI: 0.83-0.96).
The prevalence of infection significantly increased with age and was higher in urban (21.1%)
than in remote (15.5%) and rural areas (16.4%) (p=0.034) for urban areas compared to rural
and remote areas taken together). The prevalence of TST positive was also higher in South
(19.8%) than in North (15.9%) and Central Vietnam (15.0%) (p=0.008 for the South compared
to North and Central Vietnam taken together). There was no difference in the prevalence of
TST positive between different SES (Table 1).
The results of multivariate analysis, adjusted for BCG scar, sex, age, areas (urban, rural,
remote) and zones (North, Center, South) of residence and SES are shown in Table 2. The
prevalence of TST positive was lower in the group without BCG scar than in the group with
BCG scar (OR=0.65; 95% CI: 0.58-0.73), in girls than in boys (OR=0.89; 95% CI: 0.83-0.96);
and in the middle and highest than in lowest SES classes (OR = 0.89; 95% CI: 0.81-0.97 and
0.88; 95% CI: 0.80-0.97, respectively). The prevalence of TST positive was higher in the
South than in the North (OR=1.28, 95% CI: 1.18-1.40), in urban than in rural areas (OR = 1.47;
95% CI: 1.34-1.62).
When we applied a cut-off ≥ 17 mm, we found similar adjusted odds ratios in the multivariate
model for BCG scar, sex and age. The association between TST positive prevalence and
urban compared to rural areas became more pronounced (OR=1.74, 95% CI 1.4-2.1), the
association with zone changed (Central versus Northern, OR 1.32; 95%CI: 1.07-1.64; Southern
versus Northern, OR 1.01), and the association with SES disappeared completely (middle
versus low, OR 0.97; high versus low, OR 1.02). (Data not shown)
Table 3 presents the relationship between TST result and the presence of current or recent TB
in the household. As expected, the proportion of children having a positive TST was higher in
the households with current or recent TB than in households in which no TB cases had
occurred recently (OR=1.6, 95%CI: 1.3-2.0); this effect was more pronounced when a cut-off
≥17 mm was used (OR 2.5). There was no significant difference in the proportion of positive TSTs in households with current and recent TB cases, regardless of the cut-off used (Table 3). Figure 3 presents the relationship between logarithm of prevalence of TB and logarithm of ARTI by clusters. Linear regression analysis regressing the logarithm of the TB disease prevalence against the logarithm of the ARTI for each cluster showed a significant association (regression coefficient 0.54, 95%CI: 0.06-1.01, p=0.027, correlation coefficient R² 0.120) between prevalence of TB and ARTI after adjustment for area and zone of residence and SES. Thus the prevalence of TB increases by 54% for every 100% of increase in ARTI. For a cut-off ≥17 mm the regression coefficient was 0.28 (95%CI 0.05-0.50, p=0.019, R² 0.129). (Data not shown).

Discussion

In this nationwide tuberculin survey, we estimated the prevalence of tuberculosis infection in Vietnam at 16.7%, and the ARTI at 1.7% using a fixed cut-off point of 10 mm. The prevalence of TST positive and ARTI were higher in urban than in rural and remote areas, lower in the North than in the Centre and/or the South of Vietnam and increased with age. It was not or only weakly associated with SES, depending on the TST cut-off used. We found a significant association between the prevalence of infection/ARTI and the prevalence of tuberculosis at cluster level. Previously we reported the distribution of the prevalence rates of TB from the same survey and its association with SES.⁸,¹⁰ There were some striking differences in patterns: the prevalence of TST positive and ARTI were highest in urban areas whereas the prevalence of TB did not differ between urban, rural and remote areas. While the prevalence of TB decreased significantly with increasing level of SES, there was no strong association between the prevalence of TST positive and SES. A potential explanation is that the prevalence of infection measured in this survey is the result of cumulative exposure over an average of 10.8 years, while the TB prevalence in the clusters with a small number of TB cases is expected to vary randomly depend on the time of the survey. In addition, some TST positive attributable to mycobacteria other than tuberculosis (MOTT) and therefore not associated with TB exposure. Results from repeated tuberculin surveys in Vietnam show a declining trend in ARTI in 3 out of 5 sentinel provinces between surveys done from 1993 to 1997 and from 1998 to 2002, respectively. Using a cut-off point of 10mm, the average of the ARTI estimated from 7 tuberculin surveys done in the period 1986-1994 was 1.7%. In the current survey, we found the ARTI also to be 1.7%. However, data from previous studies cannot be compared to the data of the present study, since these previous surveys were done in small geographical areas and were not representative for the country as a whole.

In our population of children, 84.2% had a BCG scar and since in Vietnam is known for a high BCG vaccination coverage rate and increased with time.⁶,¹¹ Therefore a high proportion of the children without a BCG scar were probably vaccinated at birth without developing a scar. Separate analysis of the frequency distributions of induration sizes of children with and without a BCG scar showed that these were quite similar (Figure 2) though a significantly higher proportion of the children without a scar showed no reaction to tuberculin than among children with a scar (56.0% vs 43.1%, respectively, p<0.001). Therefore, we have combined both
groups, as is recommended in the most recent guidelines on the conduct of tuberculin surveys. Several studies have demonstrated that the BCG given at birth has no or little effect on the TST result in children. However, in this study, we found that the prevalence of infection was significantly higher in children with BCG scar than among children without BCG scar, this association was remain observed after adjusted for age, sex, area, zone and SES. In line with the literature, we observed that the prevalence of TST positive increased with age, presumably because older children were at risk of TB infection for a longer period of time. The same pattern was observed when we took 17 mm as the cut-off for defining TB infection.

Many previous studies have shown a relation between the rate of transmission of tubercle bacilli and the number of sources of infection in the community. Our study found an association between TST positive and the presence of TB patients in the household. The risk of being TST positive was significantly higher in households with TB patients than in households without TB patients (1.6-2.5 times, depending on the TST cut-off used from 10 to 17 mm). There was no significant difference in the risk of a positive TST in households with current (identified in the survey) compared to recent TB cases (identified by passive case finding), regardless of the cut-off value used. This indicates that those found in the prevalence survey (active case finding) are as infectious as passively detected TB cases, whereas almost half of these did not (yet) report persistent productive cough, and are thus missed with the current NTP screening guidelines. This suggests that active case finding to find non-symptomatic TB cases may be needed to substantially reduce TB transmission in the Vietnamese population.

The association between the prevalence of TB and the prevalence of TST positive by cluster was as expected. Since the regression was on a logarithmic scale, the association translates into an increase in prevalence of TB by 32% from 145 to 191/100,000 if the observed ARTI of 1.67% would increase by a full percentage point to 2.67 (based on a TST cut-off of 10 mm). However, the R-square values were small, suggesting that only a small proportion of the observed variation in TB prevalence rates can be explained by the prevalence of TST positive. The association between prevalence of TB and prevalence of infection have causal chain, as in community have high TB prevalence leads to high prevalence of infection because of transmission, and in contract, high prevalence of infection leads to high TB incidence and thus TB prevalence. Future studies should investigate a potential association between these rates more thoroughly.

For identified tuberculosis positive, we choose 10 mm as cut-off point. However, considering the association of TB infection prevalence with BCG vaccination status and the relatively high ratio of TB infection prevalence per prevalent TB patient, the 10 mm cut-off point may include nonspecific reactions. We therefore conducted the analysis using cut-off points 17 mm, in multivariable analysis, the significant difference in TB infection prevalence between zone (Southern versus Northern) and between difference levels of SES were disappeared. This may be explained by cross-reactions being more frequent in the South than in the North in Vietnam, probably reflecting a difference in the prevalence of MOTT, which may also be associated with SES.

The strength of this survey is that it included a nationwide, representative sample, combined with the national tuberculosis prevalence survey with a high participation rate (92.8%) compared with others.
Our study had limitations. First, the annual risk of infection as calculated from tuberculin surveys requires several assumptions, such as the risk of acquisition of infection is constant over time, and the risk of acquisition of infection in children is the same as that in the rest of the population, and these assumptions are questionable in a rapidly changing country as Vietnam. Second, all tuberculin surveys face methodological difficulties in interpretation of their results. Third, nonspecific reactions resulting from infection with MOTT and BCG occur at different proportions in the three geographical zones of Vietnam. Fourth, our data show strong digit preference in TST reading. Fifth, it is difficult to obtain a useful and valid cut-off point, especially if the TST results show no clear bimodal distribution as in our study. Finally, this was a cross-sectional survey, thus, although we showed that there is an association between TB infection in children and presence of a TB case in the household, our data do not provide clues about where and by whom the children were infected nor which of the children will get TB.

Conclusions

This is a report of the first nationwide tuberculin survey in Vietnam. Using a cut-off point of 10 mm, the estimated ARTI was 1.7% in the whole country. Children living in households with a recent TB patient had a higher probability of being infected with M. tuberculosis than children belonging to households were no recent TB cases were identified. Although our data indicate that there an association between the prevalence of TST positive and ARTI with the prevalence of TB, this association needs more investigation.

Acknowledgements

The authors thank the NTP directory board and all national, regional, provincial, district, and commune level staff involved in the survey, and all the individuals living in the study sites for taking part in the study.

The prevalence survey was supported financially by the Vietnamese Ministry of Health, the Government of the Netherlands, KNCV Tuberculosis Foundation, the Global Fund against AIDS, Tuberculosis and Malaria, and the World Health Organization.

None of the authors had any conflict of interest to be declared.

References


Table 1. Estimated prevalence of infection and annual risk of tuberculosis infection (ARTI), using 10 mm cut-off, among children 6-14 years old by BCG status, sex, age, areas and zones, in the first Vietnam national tuberculin survey, 2006-2007.

<table>
<thead>
<tr>
<th>Category</th>
<th>Test-read (n)</th>
<th>Mean age (years)</th>
<th>TST positive (n, % *)</th>
<th>P value</th>
<th>ARTI (%) (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>21,487</td>
<td>10.8</td>
<td>3810 (16.7)</td>
<td>0.004</td>
<td>1.7 (1.5 - 1.8)</td>
</tr>
<tr>
<td>BCG</td>
<td>17,757</td>
<td>10.7</td>
<td>3257 (17.2)</td>
<td>1.7</td>
<td>1.6 - 1.9</td>
</tr>
<tr>
<td>non-BCG</td>
<td>3,328</td>
<td>11.4</td>
<td>446 (13.1)</td>
<td>1.2</td>
<td>1.0 - 1.5</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td>0.022</td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>11,058</td>
<td>10.8</td>
<td>2052 (17.4)</td>
<td>1.8</td>
<td>1.6 - 1.9</td>
</tr>
<tr>
<td>Girls</td>
<td>10,365</td>
<td>10.8</td>
<td>1751 (15.9)</td>
<td>1.6</td>
<td>1.4 - 1.8</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>6 year old</td>
<td>2,010</td>
<td>6.5</td>
<td>171 (7.5)</td>
<td>1.2</td>
<td>0.9 - 1.5</td>
</tr>
<tr>
<td>7 year old</td>
<td>2,152</td>
<td>7.5</td>
<td>250 (10.5)</td>
<td>1.5</td>
<td>1.3 - 1.7</td>
</tr>
<tr>
<td>8 year old</td>
<td>1,924</td>
<td>8.5</td>
<td>289 (13.4)</td>
<td>1.7</td>
<td>1.4 - 2.0</td>
</tr>
<tr>
<td>9 year old</td>
<td>2,185</td>
<td>9.5</td>
<td>342 (14.7)</td>
<td>1.7</td>
<td>1.4 - 1.9</td>
</tr>
<tr>
<td>10 year old</td>
<td>2,366</td>
<td>10.5</td>
<td>427 (17.0)</td>
<td>1.8</td>
<td>1.5 - 2.0</td>
</tr>
<tr>
<td>11 year old</td>
<td>2,477</td>
<td>11.5</td>
<td>497 (19.9)</td>
<td>1.9</td>
<td>1.6 - 2.2</td>
</tr>
<tr>
<td>12 year old</td>
<td>2,810</td>
<td>12.5</td>
<td>567 (19.7)</td>
<td>1.7</td>
<td>1.5 - 2.0</td>
</tr>
<tr>
<td>13 year old</td>
<td>2,804</td>
<td>13.5</td>
<td>616 (21.0)</td>
<td>1.7</td>
<td>1.5 - 2.0</td>
</tr>
<tr>
<td>14 year old</td>
<td>2,759</td>
<td>14.5</td>
<td>651 (21.4)</td>
<td>1.7</td>
<td>1.4 - 1.9</td>
</tr>
<tr>
<td>Areas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>4,749</td>
<td>10.7</td>
<td>1078 (21.1)</td>
<td>0.034</td>
<td>2.2 (1.6 - 2.8)</td>
</tr>
<tr>
<td>Remote</td>
<td>7,187</td>
<td>10.8</td>
<td>1146 (15.5)</td>
<td>0.217</td>
<td>1.6 (1.4 - 1.8)</td>
</tr>
<tr>
<td>Rural</td>
<td>9,551</td>
<td>10.9</td>
<td>1586 (16.4)</td>
<td>0.655</td>
<td>1.6 (1.4 - 1.9)</td>
</tr>
<tr>
<td>Zones</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North</td>
<td>10,548</td>
<td>10.9</td>
<td>1701 (15.9)</td>
<td>0.264</td>
<td>1.6 (1.4 - 1.8)</td>
</tr>
<tr>
<td>Middle</td>
<td>3,941</td>
<td>10.8</td>
<td>635 (15.0)</td>
<td>0.273</td>
<td>1.5 (1.1 - 1.9)</td>
</tr>
<tr>
<td>South</td>
<td>6,998</td>
<td>10.7</td>
<td>1474 (19.8)</td>
<td>0.008</td>
<td>2.1 (1.8 - 2.4)</td>
</tr>
<tr>
<td>SES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>8,671</td>
<td>10.8</td>
<td>1527 (16.9)</td>
<td>0.740</td>
<td>1.7 (1.5 - 1.9)</td>
</tr>
<tr>
<td>Middle</td>
<td>6,154</td>
<td>10.8</td>
<td>1072 (16.3)</td>
<td>0.532</td>
<td>1.6 (1.4 - 1.9)</td>
</tr>
<tr>
<td>High</td>
<td>4,842</td>
<td>10.8</td>
<td>889 (16.9)</td>
<td>0.850</td>
<td>1.7 (1.5 - 1.9)</td>
</tr>
</tbody>
</table>

*Weighted for stratification by area, differential population growth between 1999 and 2006, and differential cluster size; 
†P value for difference between this area compared with both other areas together; between this zone compared with both other zones together; between this socio-economic class and both other socio-economic classes together.

TST: Tuberculin skin test; SES: socio-economic status, tertiles; ARTI: annual risk of infection; CI: confidence interval.
Table 2. Univariable and multivariable associations of BCG status, sex, age, area and zone of residence, and socio-economic status (SES) with infection prevalence using the fixed 10 mm cut-off point, in the first Vietnam national tuberculin survey, 2006-2007.

|                          | Infected* n/N (%) | Univariate OR (95%CI) | P value† | Multivariate OR (95% CI) | P value  \\
|--------------------------|-------------------|-----------------------|----------|--------------------------|----------
| All                      | 3810 / 21487 (17.7%) |                       |          |                          |          \\
| BCG scar                 | 3257 / 17757 (18.3%) | 1                     | < 0.001  | 1                        | < 0.001  \\
| No BCG scar              | 446 / 3328 (13.4%) | 0.69 (0.62-0.77)      |          | 0.65 (0.58-0.73)         |          \\
| Sex ‡                    |                    |                       |          |                          |          \\
| Males                    | 2052 / 11058 (18.6%) | 1                     | 0.002    | 1                        | 0.03     \\
| Females                  | 1751 / 10365 (16.9%) | 0.89 (0.83 - 0.96)    |          | 0.89 (0.83-0.96)         |          \\
| Age (years)              |                    |                       |          |                          |          \\
| 6                        | 171 / 2010 (8.5%) | 1                     | < 0.001  | 1                        | < 0.001  \\
| 7                        | 250 / 2152 (11.6%) | 1.41 (1.15-1.75)      |          | 1.43 (1.15-1.76)         |          \\
| 8                        | 289 / 1924 (15.0%) | 1.90 (1.55-2.34)      |          | 1.82 (1.48-2.25)         |          \\
| 9                        | 342 / 2185 (15.7%) | 2.00 (1.64-2.44)      |          | 1.99 (1.63-2.44)         |          \\
| 10                       | 427 / 2366 (18.0%) | 2.37 (1.95-2.87)      |          | 2.37 (1.95-2.88)         |          \\
| 11                       | 497 / 2477 (20.1%) | 2.70 (2.23-3.26)      |          | 2.75 (2.27-3.33)         |          \\
| 12                       | 567 / 2810 (20.2%) | 2.72 (2.26-3.27)      |          | 2.85 (2.36-3.44)         |          \\
| 13                       | 616 / 2804 (22.0%) | 3.03 (2.52-3.64)      |          | 3.23 (2.68-3.90)         |          \\
| 14                       | 651 / 2759 (23.6%) | 3.32 (2.76-3.99)      |          | 3.58 (2.97-4.32)         |          \\
| Area                     |                    |                       |          |                          |          \\
| Rural                    | 1586 / 9551 (16.6%) | 1                     | 1        | 1                        | 1        \\
| Urban                    | 1078 / 4749 (22.7%) | 1.47 (1.35-1.61)      | < 0.001  | 1.47 (1.34-1.62)         | < 0.001  \\
| Remote                   | 1146 / 7187 (15.9%) | 0.95 (0.88-1.04)      | 0.252    | 1.03 (0.94-1.13)         | 0.485    \\
| Zone                     |                    |                       |          |                          |          \\
| North                    | 1701 / 10548 (16.1%) | 1                     | 1        | 1                        | 1        \\
| Central                  | 635 / 3941 (16.1%) | 1.00 (0.90-1.10)      | < 0.001  | 0.90 (0.81-1.01)         | 0.067    \\
| South                    | 1474 / 6998 (21.1%) | 1.39 (1.28-1.50)      | < 0.001  | 1.28 (1.18-1.40)         | < 0.001  \\
| SES **                   |                    |                       |          |                          |          \\
| Low SES                  | 1527 / 8671 (17.6%) | 1                     | 1        | 1                        | 1        \\
| Middle SES               | 1072 / 6154 (17.4%) | 0.99 (0.90-1.08)      | 0.763    | 0.89 (0.81-0.97)         | 0.011    \\
| High SES                 | 889 / 4842 (18.4%) | 1.05 (0.96-1.15)      | 0.275    | 0.88 (0.80-0.97)         | 0.012    \\

* Tuberculin skin testing (TST) reaction >= 10 mm
† Based on chi-square test
‡ The total does not add up to 21487 children because of missing information
** Socio-economic status, tertiles
Table 3. Relationship between tuberculin skin testing (TST) results among children between 6 and 14 years old and tuberculosis (TB) patients within households, in the first Vietnam national tuberculin survey, 2006-2007.

<table>
<thead>
<tr>
<th>History of TB in the household</th>
<th>N of children</th>
<th>N TST positive (%)</th>
<th>OR (95% CI)</th>
<th>N TST positive (%)</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None in the past 2 years</td>
<td>21055</td>
<td>3699 (17.6)</td>
<td>1.0 (ref)</td>
<td>662 (3.1)</td>
<td>1.0 (ref)</td>
</tr>
<tr>
<td>≥1 TB cases in the past 2 years</td>
<td>432</td>
<td>111 (25.7)</td>
<td>1.6 (1.3-2.0)</td>
<td>32 (7.4)</td>
<td>2.5 (1.6-3.6)</td>
</tr>
<tr>
<td>≥1 TB cases in the past 2 years but no current case</td>
<td>243</td>
<td>60 (24.7)</td>
<td>1.0 (ref)</td>
<td>13 (5.4)</td>
<td>1.0 (ref)</td>
</tr>
<tr>
<td>≥1 current TB cases</td>
<td>189</td>
<td>51 (27.0)</td>
<td>1.1 (0.7-1.8)</td>
<td>19 (10.1)</td>
<td>0.87 (0.38-1.92)</td>
</tr>
</tbody>
</table>

*Abbreviations in this table: TST: tuberculin skin testing reaction; TB: tuberculosis; OR: odds ratio; CI: confidence interval; ref: reference
Figure 1. Overview of the National tuberculin survey in Viet Nam, 2006 – 2007

Number of children in the clusters studied
N= 23,160

Number of children present at testing day N=22,585 (97.5%)

Number of children injected
N=22,427 (96.8%)

Number of children of whom test result was read
N= 21,487 (92.8%)
Figure 2. Frequency distribution of reaction sizes among children aged 6-14 years, by BCG scar in Viet Nam, first national tuberculin survey, 2006-2007.*

* Excluded were children with no TST reaction (0 mm): 7663 children with and 1865 children without a BCG scar, and 402 children without information on their BCG status.
Figure 3: Logarithm of prevalence of tuberculosis and logarithm of annual risk tuberculin infection (ARTI) by cluster in first national tuberculin survey, 2006-2007 in Vietnam.