Risk of developing tuberculosis from a school contact: retrospective cohort study, United Kingdom, 2009

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To quantify the risk of developing tuberculosis (TB) following school contact with a student with smear positive respiratory TB in a population with a high background rate of tuberculosis, a retrospective cohort study was conducted. This study included all students and staff (n=1,065) at an inner city secondary school in Birmingham, United Kingdom (UK). Being in the same school year as the index case resulted in a significantly higher risk of being diagnosed with active TB (odds ratio (OR) 6.11) and either active or latent TB (OR 10.52) compared to the risk for pupils in other school years. Neither lower level classroom exposure in tutoring groups nor being a staff member resulted in significantly increased risk of infection. The number of cases detected in the school was significantly higher than compared with the TB notification rate for the respective age groups in the population in the area. This study is consistent with the small body of evidence that already exists suggesting that greater levels of classroom contact with a student with smear positive active TB significantly increases the risk of contracting active and latent TB. It also suggests that staff may be at a lower risk of active TB than students. It does not appear that being in an area with high TB incidence substantially alters the epidemiology of the outbreak or risk of transmission between students in comparison to other populations.

Introduction

Historically tuberculosis (TB) has been a major cause of premature death in the United Kingdom (UK). It remains a serious disease and active TB can lead to death if not treated. An outbreak of TB in a school often causes major concern for children and parents and generates significant volumes of work for health-care organisations. In these situations it is important that action is based on robust scientific evidence to ensure that the correct response is being applied. However, the current evidence base for the management of a school-based outbreak of TB is small and increasing the size of this will ensure that screening strategies are both safe and effective in identifying those with infection.

The evidence base for the United Kingdom's National Institute for Health and Clinical Excellence (NICE) recommendations for management of TB in schools [1] refers to five analytical studies [2-6] none of which are UK based, nor conducted in areas of high local prevalence of TB or where the majority of students are from black or minority ethnic (BME) groups. Of these studies only three have provided estimates of the relative risk to children and staff within the school following a case of smear positive (open) TB in a school pupil.

We conducted a retrospective cohort study following a large school-based TB outbreak in a state funded secondary school in the inner city of Birmingham, UK. Over 95% of the school's students were from BME groups and all were aged 10-16 years. The school was located in an area of central Birmingham with a high proportion of residents from a BME group (68%) [7] and one of highest incidence rates of tuberculosis in England [8]. In 2006 and 2007 it had a direct standardised incidence rate for TB of 109.6 and 99.4 cases per 100,000 population, respectively [9] compared with the UK average of 13.8 per 100,000 [10]. In both the 10-14 and 15-19-year-old age groups in the school uptake area the TB incidence was 105.7 per 100,000 in 2007 [8].

The index case for the outbreak was a 16-year-old male who was diagnosed with smear positive respiratory TB in December 2008. He had been increasingly unwell with cough and weight loss since September 2008. He had attended the school as usual for the majority of this time after which he received antimicrobial therapy and became smear negative. Initially the students in the same school year as the index case were screened for TB in February 2009. As a result of this screening which yielded several secondary cases of active TB, the whole school population was offered screening as advised by national guidance [1]. Screening of the whole school was carried out in April 2009.

This study aims to:

- Identify the risks of developing tuberculosis following different types of school contact with a child with smear positive respiratory TB.
- Quantify the magnitude of these risks.

Methods

Study population

The study population comprised all students (886) and staff members (179) who attended or worked at the school between September 2008 and April 2009 (n=1,065). The student population was evenly split between five school years (173-189 pupils in each year). Students in the same school year were all of a similar age.

Outcome measures and case ascertainment

The primary outcome measure was the diagnosis of active TB infection requiring full antimicrobial treatment by a physician specialising in infectious or respiratory diseases. The secondary outcome measure was the diagnosis of active or latent TB requiring chemoprophylaxis according to local TB screening protocols.

Students were screened by Mantoux testing. All students with a positive Mantoux result (greater than 15 mm if Bacillus Calmette-Guérin (BCG) vaccinated, greater than 5 mm if unvaccinated) were referred for further clinical assessment. All staff were over 18 years of age and were offered screening by chest radiograph or Mantoux testing if pregnant. All staff with an abnormal chest radiograph or a positive Mantoux result were referred for clinical assessment.

All patients referred were assessed for TB infection by at least clinical history, clinical examination, chest radiograph and gamma interferon test (T-spot), plus microscopic examination of sputum if coughing. More invasive diagnostic testing was carried out as clinically indicated. Diagnosis of latent or active tuberculosis was made by a consultant respiratory physician.

Measurement of exposure

Data were collected for each subject during the co-ordinated health service response to the outbreak, including information on date of birth, address, history of BCG vaccination and for students, school year and tutoring group.

Students from different school years did not mix for lessons but there was significant mixing of students within a school year for lessons. Class sizes varied from approximately 20-35 students. The only formal mixing of students between years was as part of a tutor

Table 1

Outcomes of tuberculosis exposure groups under study, United Kingdom, 2009 (n=1,065)

	Pupils	Staff	Same school year as index case	Other school year	Same tutor group as index case	Other tutor group
Active tuberculosis	12	0	7	5	0	12
Latent tuberculosis	55	0	37	18	1	54
No evidence of tuberculosis	698	172	103	595	15	683
Did not attend screening	121	7	23	98	2	119
Total	**886**	**179**	**170**	**716**	**18**	**868**

Table 2

Results of logistic regression analysis of exposure factors to the risk of being diagnosed with active or latent tuberculosis, United Kingdom, 2009

Risk of being diagnosed with active tuberculosis			
Exposure	**Odds ratio**	**95% Confidence interval**	**p-value**
Staff member (versus pupil)	0	0	0.99
Male	0.89	0.28-2.84	0.85
Previous BCG vaccination	2.83	0.36-22.09	0.32
Same tutor group as index case	0	0	0.99
Same school year as index case	6.11	1.91-19.48	0.002
Risk of being diagnosed with active or latent tuberculosis			
Exposure	**Odds ratio**	**95% Confidence interval**	**p-value**
Staff member (versus pupil)	0	0	0.99
Male	1.12	0.68-1.85	0.66
Previous BCG vaccination	1.32	0.68-2.58	0.41
Same tutor group as index case	0.71	0.09-5.45	0.75
Same school year as index case	10.52	6.14-18.03	<0.0001

BCG: Bacillus Calmette-Guérin

group where a total of 18 students from different years shared a classroom weekly for 1.5 hours per week.

For students, two measures of increased exposure were used; being in the same school year with the index case (three 30 hours of classroom exposure per week) and being in the same tutoring group (tutor groups included students from all school years, sharing a tutoring group equated to 1.5 hours classroom exposure per week). Students not in the same tutor group or school year were classified as having low school exposure (less than 1.5 hours per week). For staff substantial exposure was defined as those who had prolonged and direct contact with the index case. This exposure was assessed clinically by interview as part of a risk assessment for each staff member.

Statistical analysis

Standard descriptive statistics were used to summarise the data. The relationship between exposure and outcomes was analysed using logistic regression which allowed the effect of interactions between exposure categories on outcomes to be assessed. Reported p-values are all two-sided. Except where stated otherwise, the control group was all students classified as the low exposure group. Comparisons of risk were made with (i) those in the same school year as the index case, and (ii) those in the same tutor group as the index case and staff. The chi-square test was used to assess differences in the rate of TB infection between the school population and the overall rate seen in school uptake area population [8] All analysis was carried out using SPSS version 15.

Results

All students at the school were aged between 10 and 16 years at the time of investigation, all of which were included in the study. The study also included all staff members employed at the school during the study period.

All students and staff were offered screening. Staff numbered 179 and of these 172 participated (96.1%). There were 886 students and of these 765 (86.3%) participated. The remainder, 121 pupils and seven staff, declined screening. Complete data are available for all participants. The outcomes for the different groups under study are presented in Table 1.

Being in the same school year as the index case resulted in a significantly higher risk of having active TB (OR 6.11) and either active or latent TB (OR 10.52) (Table 2). The lower level of classroom exposure of those attending the same tutoring groups did not result in any significantly increased risk. No staff member was diagnosed with active or latent TB.

Previous BCG vaccination did not significantly reduce the risk of being diagnosed with active or latent TB.

Multiple logistic regression analysis showed no significant interaction between exposure categories on outcomes.

Applying the age specific rate of TB infection of the school uptake area population [8] to the school population it would be expected that there would be 0.94 cases of TB diagnosed per year. This is significantly lower than the actual number seen in our outbreak investigation (chi-square p=0.002).

Discussion

The study supports current recommendations for management of TB cases in schools. The highest level of risk of being diagnosed with active or latent TB and therefore priority area of concern is children in the same school year as the index case. The increased level of exposure seen in other groups did not translate to substantially increased risk of infection. While we would not suggest that teachers with substantial levels of exposure should not be tested for TB in school based outbreaks, these results suggest they can be reassured they are unlikely to be at higher levels of risk for contracting active TB.

It is possible that the high numbers of students diagnosed with active TB in our study were due to the high incidence rate in the population. However, the large and significant difference between the expected number of cases in the school and the number actually found makes it unlikely that the majority of cases detected by screening were due to previously undiagnosed TB acquired in the wider community. In addition, three cases with active TB had their *Mycobacterium tuberculosis* strains molecularly typed by DNA fingerprinting. All of them were indistinguishable from one another and identical to the strain found in the index case which strongly supports the school being the place of transmission.

This study adds to the small evidence base related to school based TB outbreaks. A particular strength of the study is the size of the population, which is larger than most of the other published studies [2,3,6] and the relatively low proportion of the population that did not attend screening which increases the reliability of the results.

The most significant limitation of this study is the sole use of chest radiograph in the screening of non-pregnant staff members. UK guidance recommends that this is satisfactory for those aged over 35 years and have had previous BCG vaccination [1]. However, those that do not satisfy these criteria should ideally be screened by Mantoux testing. Due to the limitation of the data available we were unable to estimate what proportion of staff should ideally have had Mantoux testing. Therefore caution should be used when interpreting the prevalence of latent TB in the staff population. However, the results for the prevalence of active TB in the staff group should still be reliable since all subjects

had either normal chest radiographs or TB excluded by a physician if the radiograph was abnormal.

Current NICE guidance quotes a relative risk for existing high school pupils compared to new school entrants of 2.3 (95% CI 1.7-3.2) [3]. Only two other studies examined the risk of classroom versus non-classroom exposure (relative risk (RR) 2.3 95% CI 1.4-3.8) [2], (RR 10.9 95% CI 8.7-13.4) [4]. We have reported OR because of the use of logistic regression and although not the same as RR their values become increasingly similar as the ratio of subjects without disease to those with disease increases above 6:1. This study's main finding of the risk of students in the same school year developing active TB has a ratio of approximately 24:1. Therefore we can be confident that the values of the OR presented here can be directly compared to the RR reported in previous studies without the need for statistical correction.

A number of other papers have discussed the epidemiology of school outbreaks but have not formally quantified risk. No studies were found that quantified the risk to staff of contracting TB from students although studies exist that examined risks to students taught by staff with open TB [11].

The results of this study are consistent with other studies published on school-based TB outbreaks and confirm that higher levels of classroom exposure to people with open TB significantly increase the risk of being diagnosed with active or latent TB. It also suggests that the risk to staff may be very small when teaching children who have open TB although more research is required to confirm this. It does not appear that being in an area of high background TB incidence substantially alters the epidemiology of the outbreak or risk of transmission between students in comparison to other populations and that there is no evidence that alternative screening strategies are required in this situation.

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