Epidemiol. Infect. (1999), **123**, 445–450. Printed in the United Kingdom

Risk of transmission of tuberculosis among inmates of an Australian prison

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(*Accepted 19 August 1998*)

SUMMARY

In a prison in Victoria, Australia, our objectives were contact tracing of inmates and staff at risk of exposure to an identified index case; and to determine risk factors for prevalent and incident infection. Inmates and staff who were potentially exposed to the index case were screened with a Mantoux skin test and a questionnaire. Inmate movements within the prison were compared to movements of the index case. Logistic regression was used to determine risk factors for infection. The index case had smear positive, cavitating pulmonary tuberculosis (TB), which was undiagnosed for 3 months. This was the period of potential exposure. The prevalence of positive skin test reactions in 190 inmates and staff at the prison was 10%. Significant predictors of a positive skin test were being an inmate (odds ratio (OR) 15·5), older age (OR 8·3) and being born overseas (OR 10·7). Bacille Calmette Guerin (BCG) vaccination, proximity to the index case in various prison sites, duration of incarceration, number of incarcerations and number of inmates per cell were not significant. There were three recent skin test conversions from negative to positive, representing a conversion rate of 3·5%. We did not find evidence of significant transmission of TB from a single index case. The prevalence of infection in this Australian prison was lower than published rates in other countries. Better prison conditions and different demographics of prison inmates in Australia may explain these differences.

INTRODUCTION

Outbreaks of tuberculosis (TB) in prisons have been well documented in other countries [1, 2], making these sites important targets for TB control. Prevalence rates of up to 25% have been described in correctional institutions in the United States [3–7]. Infectious tuberculosis in prison inmates can be spread back into the community [3] as well as within the prisons. The factors associated with the transmission of tuberculosis in US prisons include the high prevalence of infection in the source population, HIV infection, overcrowding and systematic rotation of prisoners. In countries such as France and the USA, HIV seroprevalence of 8·5–11% has been described in prison inmates [8, 9]. In contrast, a serosurvey in Victoria, Australia, showed only 0·5% of inmates to be infected [10], so that HIV as a co-factor in TB transmission does not appear to be as important in Australia.

Stead described conversion from negative to positive tuberculin skin test (TST) status among 12% of prisoners exposed to infectious tuberculosis in the

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United States [3]. In Australia, there is no evidence of a significant problem of TB control in prisons, which are less crowded and better resourced compared to US prisons. Different demographics and risk levels in Australia compared to the United States, where most of the studies of TB in prisons have been done, may also be an important difference.

In June 1997, the Victorian State Department of Human Services was notified of a case of pulmonary TB in an inmate of a Melbourne prison ('prison A'). Victoria is the second most populous state in Australia, with a population of approx. 5 million. The inmate was aged 38 years, and had been symptomatic since March 1997, 3 months prior to diagnosis. His symptoms included fever, cough and weight loss. He was found to be smear positive (3+), culture positive, with cavities in both apices on chest radiograph (CXR). The isolate of *Mycobacterium tuberculosis* grown from this patient was sensitive to all drugs.

The index case was born in Hong Kong to British parents, and had lived in Singapore until the age of 18, when he moved to Australia. He had a 20-year history of intravenous drug use, and had been in a Thai prison for drug-related offences in 1986–7 and again in 1990. On returning to Australia in 1991, he was incarcerated again for possession of drugs. During this incarceration at a different Victorian prison, he was stated to have had a screening CXR, which was apparently 'clear'. This result, and the reason for having a CXR cannot be verified. After serving that sentence, he was incarcerated again in October 1995 in prison A. He spent most of his time alone in his cell, except for inmate work activities. He worked in the prison woodwork shop for 1 month in 1995, in the prison kitchen until February 1997, and in the prison education centre from February 1997 until the time of diagnosis of TB. The long interval between the onset of symptoms and initiation of treatment necessitated an extended contact survey in the prison.

Prison A is a medium security facility which houses approx. 100 inmates. There are approx. 50 full-time staff members. Areas where inmates mingle include the dining room, kitchen, educational centre, workshop, laundry and visitors centre. Inmate accommodation includes single cell, two to a cell, and four to a cell. The index case spent most of his time in his cell and in the educational centre.

The Department of Human Services TB Program conducted a contact tracing survey in Victorian prisons in response to this case.

The aim of this investigation was contact tracing of inmates and staff at risk of exposure to the index case in prison A and determining risk factors for infection.

METHODS

A contact investigation was conducted in prison A. Testing was voluntary. We tested staff and inmates who had worked or resided at prison A during the period of potential exposure, February–June 1997. Staff or inmates who had potentially been exposed (on the basis of having worked at prison A during the period of exposure) but had been transferred to another prison were also tested. There were 200 inmates and staff meeting these criteria. We tested 190/200. The remainder were not tested because they were inmates who had been discharged from the prison and could not be contacted. There were no refusals. Skin testing was done in June 1997, and repeat testing of negative reactors was performed in September 1997. Skin testing was done using the Mantoux method, with 10 tuberculin units of purified protein derivative, by nurses from the TB programme who are experienced at performing and reading the tuberculin skin test (TST). Past BCG vaccination status was ascertained by examining the arms for a scar consistent with BCG vaccination and by history. A positive test was defined as a skin test reaction of 15 mm or more, post-BCG, or 10 mm or more without BCG; Recent skin test conversion was defined as a documented increase in skin test reaction size of at least 10 mm, within 24 months of an initial negative test.

A questionnaire was administered to all inmates and staff who were screened. We collected details of demographics (including age and country of birth), past BCG history, past skin testing history, past TB history and movements within the prison. Responders were asked if they spent time regularly (defined as at least weekly) in any particular part of the prison. Inmate questionnaires collected additional specific information on duration of incarceration, number of past incarcerations, 'out-work' (some inmates are allowed to work outside of the prison) and cell type (single cell or shared). Staff questionnaires collected specific additional information on duration of employment and employment status (full time or part time).

History of past screening was verified where data were available. A previous skin test survey was done by the TB programme in 1995, so that inmate and self

Table 1. *Demographic characteristics of staff and inmates*

	Total	Inmates	Staff	OR (95% CI)
No. in prison A	131	81	50	
No. in other prisons	59	55	4	
Mean age (years)	34	30	45	
% Foreign-born (no.)	19% (36/190)	21% (28/136)	15% (8/54)	1·5 (0·6–3·9)
Mean duration of incarceration or employment in prison (years)		1·1	9	
% BCG vaccinated (no.)	49% (93/190)	40% (55/136)	70% (38/54)	0·3 (0·14–0·59)

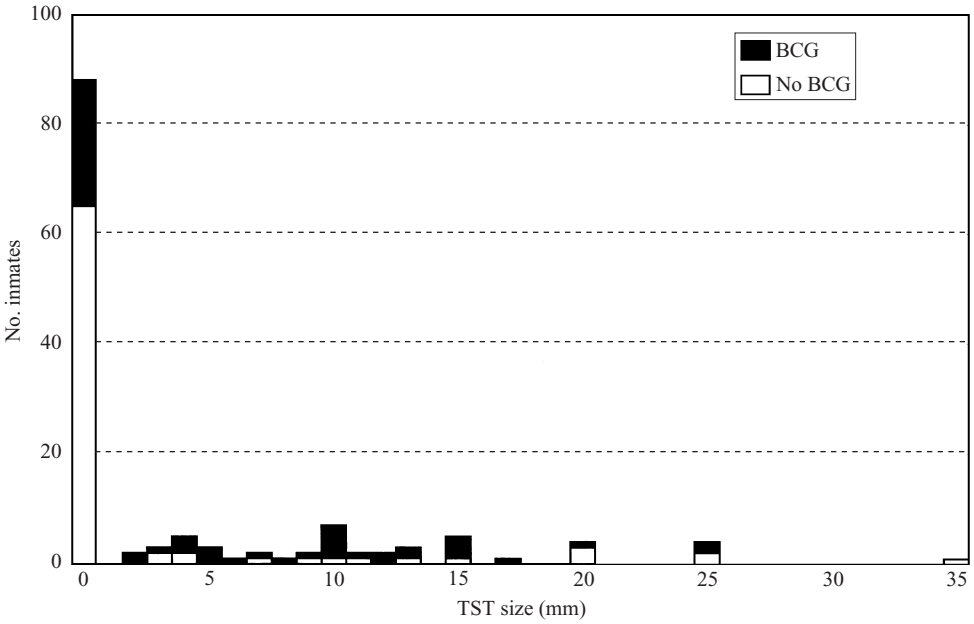

Fig. 1. TST reactions in inmates, by BCG status.

histories of skin test results from 1995 were verified using the Department of Human Services screening database.

Univariate analysis was performed in Epi-Info 6 [11]. Logistic regression was performed in Egret (Statistics and Epidemiology Research Corporation, 1985–93, no. 25). Egret calculates *P* values based on the Wald test statistic. The two outcome variables defined were an initial positive test; and recent skin test conversion. These were tested against a number of potential predictors of risk, and best models were selected by discarding clinically and statistically non-significant variables.

Attempts were made to locate inmates who had been released or transferred after the first test and required a second TST. Released inmates were contacted by mail and telephone, with the assistance of the Department of Justice.

RESULTS

Demographics

Of 200 staff and inmates 190 were tested during the first round of testing in June 1997. Table 1 describes the demographic characteristics of staff and inmates, and shows that there were differences between these two groups in age distribution and rates of BCG vaccination. Staff had worked in the prisons for a mean of 9 years (median 8 years). Only 15·4% of staff

https://doi.org/10.1017/S095026889900312X Published online by Cambridge University Press

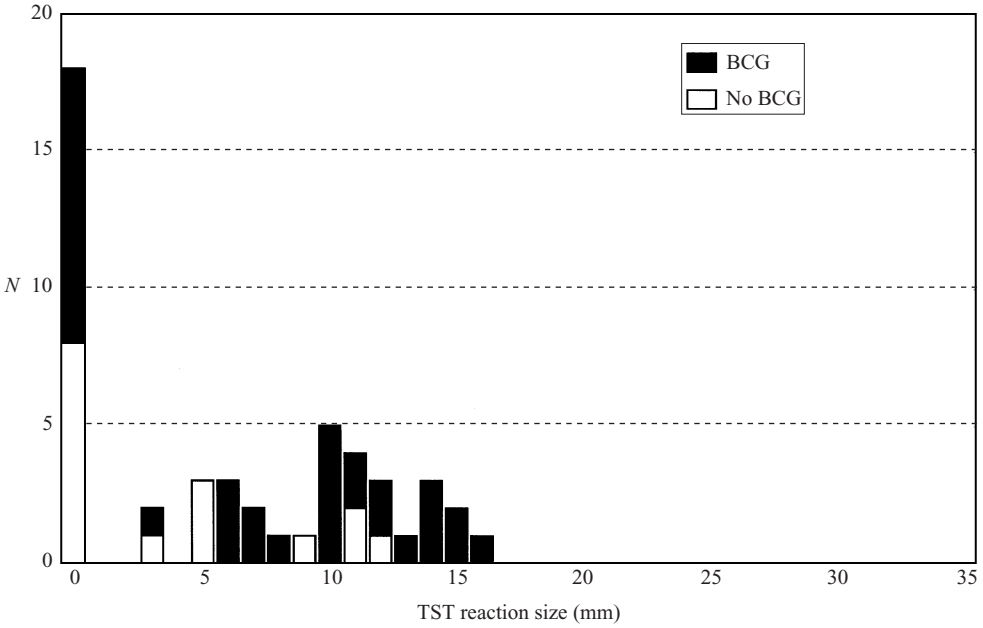

Fig. 2. TST reactions in staff, by BCG status.

Table 2. *Logistic regression model of predictors of a positive (> = 15 mm with past BCG or > 10 mm without BCG) skin test for staff and inmates*

Variable	OR	95% CI	P
Inmate	15·5	1·1–214	< 0·05
Regular attendance at education centre	1·9	0·46–8·2	0·37
Regular attendance at the medical centre	1·4	0·26–5·5	1·0
Regular attendance at gymnasium	0·98	0·2–4·9	1·0
Regular attendance at dining room	0·99	0·17–5·6	1·0
Working (staff) or incarcerated (inmates) for > 3 years	0·7	0·1–4·9	0·70
BCG vaccination	1·9	0·4–14·2	0·33
Regular attendance at visitors centre	0·11	0·01–0·97	< 0·05
Age > 35 years	8·3	2–50	< 0·01
Foreign born	10·7	2·6–44	0·001

had worked in the prisons for 1 year or less. The mean duration of incarceration for inmates was 1·1 years (median 1 year) and 70% (94/136) of inmates had one or more past incarcerations.

Tuberculin skin test reactivity

Overall, 26% (49/190) of those tested had a reaction of > 10 mm, and 10% (18/190) met the Australian definition of a positive reaction (> 15 mm if past BCG, or > 10 mm if no BCG). Staff had a higher prevalence of skin test reactions of 10 mm or more (37%, 20/54) compared to inmates (21%, 29/136), but inmates had a higher prevalence of positive reactions as defined in Australia (11%, 15/136 compared to 6%, 3/54). These differences were not statistically significant. Figures 1 and 2 show the skin test reaction distributions for staff and inmates by BCG status.

Table 2 shows the best logistic regression model for risk factors for prevalent infection for inmates and staff combined. In this model, attendance at the education centre (where the index case spent most of his time) was not significantly associated with risk, but regular attendance at the visitors centre was associated with reduced risk. Other significant associations with risk were being an inmate (as opposed to being a staff

https://doi.org/10.1017/S095026889900312X Published online by Cambridge University Press

Table 3. *Logistic regression model of predictors of a positive (> = 15 mm with past BCG or > 10 mm without BCG) skin test for inmates only*

Variable	OR	95% CI	*P* value
Current residence in prison A	2·7	0·54–13·8	0·22
BCG vaccination	1·4	0·37–5·6	0·61
Regular attendance at education centre	1·6	0·37–6·8	0·53
Regular attendance at visitors centre	0·11	0·01–1·1	0·06
Foreign born	12·1	2·4–61·5	< 0·01
Age > 35 years	6·3	1·5–25·8	0·01
Shared cell	1·2	0·26–5·9	0·8
Incarcerated for more than three years	0·64	0·08–5·2	0·67
Past incarceration	1·5	0·25–8·8	0·66
Two or more past incarcerations	1·8	0·3	0·5

member), older age and being born overseas. Table 3 shows predictors of infection for inmates only. BCG vaccination, working in the education centre, visitors centre or in other sites, duration of incarceration, number of incarcerations and number of inmates per cell were not significant in any models tested.

Skin test conversions

There were 127 inmates and staff with initial reactions < 5 mm (125 in June 1997, and 2 in 1995); 85/127 were re-tested, and 3 skin test conversions of > = 10 mm within 24 months were documented. This is a conversion rate of 3·5%. Of the skin test converters, two were full-time staff members, aged 33 and 42 years, who had documented negative skin test reactions in 1995 and had a positive test on first screening in 1997 (within 24 months of the second test). No other inmates with a positive test in 1997 had a previously documented negative test. The other was an inmate aged 28 years who had never received BCG vaccine, was negative on first testing in 1997, and converted to a 13 mm reaction within 3 months. He had no known close contact with the index case. The number of skin test conversions was too small to test predictors of conversion in multivariate models.

DISCUSSION

In 1997, the prevalence of TB infection on initial testing in inmates was 11% and in staff, 6%. The rate in staff is not markedly different from the described population prevalence of 4–6% infection [12, 13]. A prison health survey in New South Wales, the largest state in Australia, found a 13% prevalence of positive skin test reactions in male inmates [14], which is comparable to our findings. The prevalence of infection in prisons is reported in other countries to be higher than in the general population. Prevalence rates of up to 25% have been described in correctional institutions [3–7]. The prevalence rate in inmates in Australia, based on our study and available data, is 11–13% [14], which is lower than that described in US prison inmates. In fact, the pre-incarceration rate in newly admitted inmates in the United States is 13% [15, 16], which indicates that inmates in Australia are a comparatively lower risk population. However, we found that inmates were significantly more likely to be infected than staff.

Other risk factors which we identified were known general community risk factors such as increased age and being born in a foreign country. The visitors centre was associated with a lower risk of infection for the combined staff and inmate population, but was not significant for inmates alone.

The rate of skin test conversion was 3·4%, which is lower than described rates of conversion in outbreaks. A contact study in a correctional facility in California demonstrated conversion in exposed employees of 6·4/100 person-years [2]. Another study reported an initial prevalence of positive TSTs of 23% among 107 inmates residing in the same tier as an infectious inmate, with 71% of initially negative reactors subsequently converting [15]. This indicates that despite the index case being high risk (in view of his positive sputum smear status and cavitation on CXR), we did not demonstrate high rates of transmission of TB within the prison. This could be explained by the fact that the index case spent a large proportion of his time alone in his cell, and did not often mingle with other inmates.

https://doi.org/10.1017/S095026889900312X Published online by Cambridge University Press

The relationship of tuberculosis infection to number of prison admissions and increasing duration of incarceration has been described previously [4, 16]. In this population, however, despite over 70% of inmates having previous incarcerations, no relationship was demonstrated between duration of incarceration or number of incarcerations and risk of infection. This could reflect the fact that inmate populations in Australia are quite different from those in the United States, where this association has been described. Other risk factors for TB such as concurrent HIV infection are less prevalent in Australian prisoners [10]. It may also reflect better inmate housing conditions in Australia compared to the United States.

Currently, most Australian prisons do not routinely screen inmates with a TST on admission, and there is no standard policy on BCG vaccination. Universal BCG vaccination was given to all school children in the state of Victoria until 1985, thus explaining the high rate of BCG vaccination in the study population.

In summary, we describe a single case of tuberculosis in an Australian prison, and the ensuing contact investigation. This contact investigation found a lower prevalence of TB infection and incidence of skin test conversion in these prison inmates compared to reported rates in other countries. This is probably explained by behavioural factors particular to the index case, demographic differences between local and overseas inmate groups and less crowded housing conditions in local prisons.

ACKNOWLEDGEMENTS

We would like to acknowledge work of the contact tracing nurses of the Department of Human Services TB Program, Anne-Marie Baker, Lyn Brown, Denise Cameron, Josie Everett, Jane Hulls, Mary McColl, Marysia Murray and Coral Sharrock, who conducted the contact tracing and screening.

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