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Non-compliance with health surveillance is a matter of Biosafety: a survey of latent tuberculosis infection in a highly endemic setting

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ABSTRACT

Objective: This study aimed at identifying demographic, socio-economic and tuberculosis (TB) exposure factors associated with non-compliance with the tuberculin skin test, the management and prevention of non-compliance to the test. It was carried out in the context of a survey of latent TB infection among undergraduate students taking healthcare courses in two universities in Salvador, Brazil, a city highly endemic for TB.

Methods: This is a cross-sectional study of 1164 volunteers carried out between October 2004 and June 2008. Bivariate analysis followed by logistic regression was used to measure the association between non-compliance and potential risk factors through non-biased estimates of the adjusted OR for confounding variables. A parallel evaluation of occupational risk perception and of knowledge of Biosafety measures was also conducted.

Results: The non-compliance rate was above 40% even among individuals potentially at higher risk of disease, which included those who had not been vaccinated (OR 3.33; 95% CI 1.50 to 7.93; p=0.0018), those reporting having had contact with TB patients among close relatives or household contacts (p=0.3673), or those whose tuberculin skin test status was shown within the survey to have recently converted (17.3% of those completing the study). In spite of the observed homogeneity in the degree of Biosafety knowledge, and the awareness campaigns developed within the study focussing on TB prevention, the analysis has shown that different groups have different behaviours in relation to the test. Family income was found to have opposite effects in groups studying different courses as well as attending public versus private universities.

Conclusions: Although the data presented may not be directly generalisable to other situations and cultural settings, this study highlights the need to evaluate factors associated with non-compliance with routine testing, as they may affect the efficacy of Biosafety programs.

ARTICLE SUMMARY

Article focus

- The reasons behind non-compliance with health monitoring are rarely investigated, even though high rates of non-compliance have been observed in several studies among groups ranging from the general population to students and healthcare professionals.
- Non-compliance with the tuberculin skin test (TST) may affect the efficacy of tuberculosis control programs.

Key messages

- Having information on the targeted disease, as well as being at risk of this disease, was found to be insufficient to ensure compliance with routine testing.
- Non-compliance with the TST was associated with socio-economic status, gender and career choice, which suggests that cultural and psychological reasons for non-compliance are shared within such groups.
- Investigation of the reasons associated with non-compliance among different groups would be a first step to improve the efficacy of Biosafety programs.

Strengths and limitations of this study

- This study was conducted only among healthcare students and within the context of a survey for latent TB infection. The risk factors found here to be associated with non-compliance may not be directly generalisable to other situations and cultural settings. This study is limited by the fact that all the information collected was self-reported, except for the frequency of non-compliance and the TST induration measurements. Unlike in other TST surveys, non-compliance due to logistics problems was addressed and minimised.

INTRODUCTION

Tuberculosis (TB) is an infectious, airborne transmissible disease with an estimated one third of the world's population infected. Healthcare workers are particularly prone to infection through contact with patients or biological samples containing *Mycobacterium tuberculosis*, the infectious agent. Therefore, in order to reduce disease spread, measures ranging from infrastructure standards (building facilities and management), to safe practice (use of individual and collective protection equipment, asepsis procedures, etc) and monitoring of workers' health are recommended.[1 2]

These measures are within the scope of Biosafety, a field of scientific knowledge that focuses on health and environmental risk containment. In spite of studies on the risk of TB transmission within healthcare facilities,[3–8] problem perception and solutions applied in the last decade have not led to significant improvement. Studies on nosocomial TB transmission have concluded that Biosafety measures are still not integrated into TB control programs in Brazil.[9–11]

Latent tuberculosis infection (LTBI) assessment among workers at risk of *M tuberculosis* exposure is recommended.[2 9] This is usually performed using the tuberculin skin test (TST) which fulfils two important functions: monitoring of TB transmission (by identifying individuals needing prophylaxis or clinical evaluation and treatment) and evaluation of the institution's infection control measures.[3 12]

In spite of the importance of the TST, studies among healthcare workers have revealed low levels of compliance even in institutions with suspected or confirmed TB patients.[4 13 14] Identifying and understanding the factors associated with non-compliance are a crucial to Biosafety strategies promoting routine health monitoring of workers exposed to *M tuberculosis* to control TB transmission.

This study aimed to investigate whether demographic and socio-economic characteristics, career choice, history of BCG vaccination, history of contact with a TB patient or previous TB diagnosis were associated with non-compliance with the TST among different groups of university students taking healthcare related courses and participating in LTBI screening conducted in the city of Salvador, Bahia, Brazil. The estimated TB incidence in Brazil is 46/100 000 inhabitants,[15] while in Salvador, the capital city of Bahia state, it is 79/100 000 inhabitants, with 3248 confirmed cases in 2009.[16]

MATERIALS AND METHODS

Participants

Students from Salvador, Bahia, Brazil were invited to participate in a TST survey from October 2004 to June 2008. The eligibility criterion was attendance at the first year of a healthcare related course (medicine, nursing, dentistry, nutrition, phonoaudiology or pharmacy at the selected public university, or medicine or physiotherapy at the selected private university). The total numbers of volunteers enrolled from each of these courses is listed in table 1.

Volunteers were enrolled with the support of each university, which publicised the study and provided background information about TB prevention (with posters in main circulation areas, leaflets and 15 min lectures during classes). Follow-up losses due to study logistics problems were minimised by locating the assessment teams in the faculties where the volunteer students attended classes, by recruiting and training volunteer monitors who kept in contact with both the volunteers and the study team and helped to remind the participants of scheduled test readings and TST reapplication, and by maintaining communication directly with each participant by email, short message service (SMS), mobile and residential phone contact. Volunteer monitors were selected from among the target students.

Data collection

A standard questionnaire was used to obtain contact information and socio-economic data, as well as to assess previous knowledge of TB, BCG vaccination status and exposure to TB patients, clinical conditions related to pulmonary diseases, and risk factors associated with TB development. Additionally, a Biosafety questionnaire was used to assess the importance given to Biosafety control measures when working in the healthcare area, the perception of occupational risk exposure and the source of information about the theme (of Biosafety) during their university course.

The TST was carried out in a double test by expert personnel.[17] One hundred microlitres of tuberculin (PPD RT 23, Statens Serum Institute, Copenhagen, Denmark) were applied intradermally in the volar surface of the right arm. A negative TST at the first reading (48–72 h after tuberculin application) was defined as a local induration diameter of <5 mm. Participants with a negative first reading were asked to repeat the test after 7–10 days in the left arm. A positive TST was defined as an induration diameter of ≥10 mm. The same students were called for reassessment 1 year later.

During each campaign, the students were individually reminded of each of the test phases by phone and/or mobile and by SMS, and by contact with volunteer monitors. Participants who failed to attend any one stage of the test were considered non-compliant.

Variables and statistical analyses

The minimum wage (MW) in Brazil was approximately US$90–244 during the study period.[18] To evaluate confounders and possible predictors of non-compliance with the TST, we have combined failure to attend the first or second application as 'non-compliance 1' (NC1), and failure to attend the first or second reading as 'non-compliance 2' (NC2) in bivariate and multivariate analyses.

The χ^2 test (applying the Yates' continuity correction where applicable) and Fisher's exact test were used to compare categorical variables. The OR and corresponding

Table 1 Characteristics of the studied population of healthcare students from Salvador, Bahia, Brazil, 2004–2008

Study population	Participants (N=1164), n (%)	Non-compliance (N=479), n (%)
Course		
Medicine	626 (53.8)	270 (56.4)
Physiotherapy	130 (11.2)	44 (9.2)
Nursing	133 (11.4)	64 (13.4)
Pharmacy	132 (11.3)	40 (8.4)
Nutrition	72 (6.2)	31 (6.5)
Phonoaudiology	43 (3.7)	19 (4.0)
Dentistry	28 (2.4)	11 (2.3)
University		
Public	564 (48.5)	265 (55.3)
Private	600 (51.5)	214 (44.7)
Age (years)		
≤Median (19 years)	621 (53.4)	235 (49.1)
>Median (19 years)	542 (46.6)	244 (50.9)
Unknown or no answer	1 (0.1)	0 (0)
Gender		
Male	422 (36.3)	187 (39.0)
Female	742 (63.7)	292 (61.0)
Family income (in MW*)		
≤5	217 (18.6)	79 (16.5)
>5	903 (77.6)	377 (78.7)
Unknown or no answer	44 (3.8)	23 (4.8)
BCG vaccination		
Yes	874 (75.2)	357 (74.5)
No	33 (2.8)	23 (4.8)
Unknown or no answer	256 (22.0)	99 (20.7)
Known contact with a patient with tuberculosis		
Yes		
Close contact (family or household)	66 (5.7)	31 (6.5)
Other	59 (10.7)	27 (5.6)
No	1017 (87.4)	412 (86.0)
Unknown or no answer	22 (1.9)	9 (1.9)
Previous diagnosis of tuberculosis		
Yes	1 (0.1)	0 (0)
No	1151 (98.9)	474 (99.0)
Unknown or no answer	12 (1.0)	5 (1.0)

*MW, minimum wage (>5 corresponds to the top half of the economic classification system adopted by Brazilian government agencies[17]).

95% CIs were also calculated. Missing data are mentioned in the tables and were not computed for the bivariate or multivariate analyses.

Two-tailed statistical tests were used. p Values <0.05 were considered significant, except for the variable 'course attended' which involved multiple tests (ie, medical versus non-medical students, nursery versus non-nursery students, etc). In this case, p values were considered significant at <0.0071, which corresponds to 0.05 divided by 7, the number of variables involved in the grouping.[19]

Multiple logistic regression analyses included the independent variables significantly associated with non-compliance in the bivariate analysis, or which could be identified as potential confounding or interacting variables in the Mantel–Haenszel stratification analysis. For 'family income', which had opposite effects in this analysis, the multivariate models were performed separately for each stratum. The best regression model was selected interactively, based on the lowest Akaike information criterion value.

The data were entered in a database using EpiData v 3.0 (The EpiData Association, Odense, Denmark) and analyses were performed using R v 2.4.0 (The R Foundation for Statistical Computing, Vienna, Austria).

Ethics statement

This study was approved by the Ethics Committee of the Centro de Pesquisas Gonçalo Moniz (CEP-CPqGM/FIOCRUZ, 19/2002) and complies with the principles of the Declaration of Helsinki, as well as with Brazilian National Health Council Resolution 196/96 Guidelines. In agreement with these standards, written informed consent was obtained from each participant. A medical appointment was offered to all participants with a positive TST, and to students initially negative who converted to a positive TST within 1 year. For individuals

with recent conversion, chemoprophylaxis was also offered.

RESULTS

A total of 1164 students (422 male, median age 19.0 years) presented for testing and were therefore enrolled in this study. Of these, 479 (41.2%) were non-compliant (figure 1). Table 1 lists the proportions of non-compliance in the different groups. Non-compliance was mainly due to failure to attend the second test application after a first negative result (p=0.0440; table 2).

Non-compliance did not differ when subjects were compared by family income (p=0.1661) or gender (p=0.1073). Participants above the median age had a higher rate of non-compliance (OR 1.34, 95% CI 1.06 to 1.71; p=0.0143).

The students had minimum contact with TB patients (only 6% reported such contact). However, we did identify one individual with a previous history of TB. For over 50% of the individuals who reported a previous TB contact, this contact was a family member and/or a member of the student's household. Overall, 46.4% of these students who were potential TB contacts failed one of the phases of the test. Non-compliance among these students was similar to that among those denying contact (p=0.3673). Moreover, students who reported no BCG vaccination (the only vaccine currently available against TB) had a higher rate of non-compliance (OR 3.33, 95% CI 1.50 to 7.93; p=0.0018), especially as a result of not repeating the test after a first negative result (OR 3.78, 95% CI 1.37 to 120.0; p=0.0068).

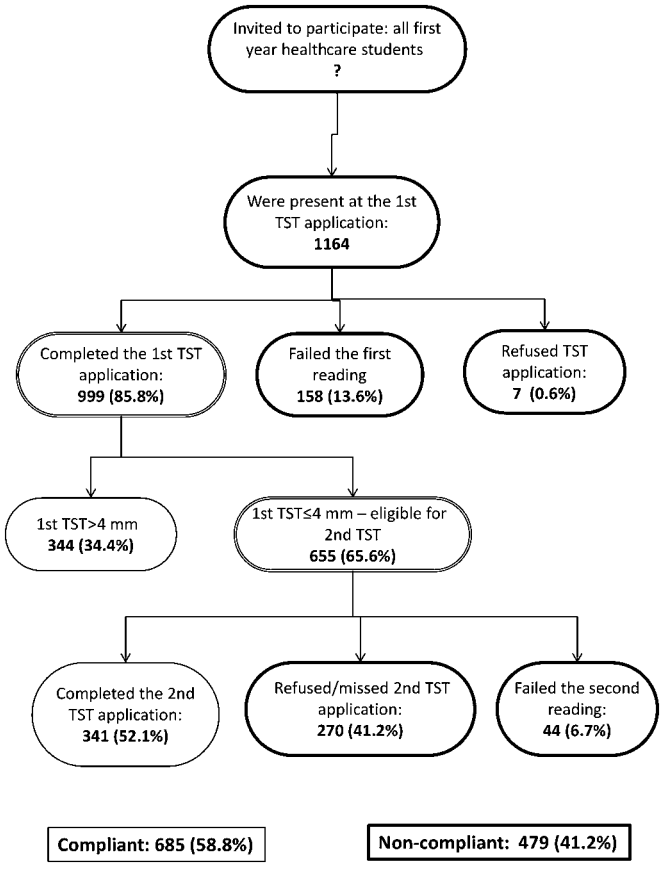

Figure 1 Attendance at the tuberculin skin test (TST) screening among healthcare students in Salvador, Bahia, Brazil, 2004–2008.

There was no association of age, income or previous contact with a TB case with any of the specific TST phases that the students missed (table 2). Male students were more likely to miss the first reading (OR 1.51, 95% CI 1.06 to 2.14; p=0.0206) as well as the second test application (OR 1.48, 95% CI 1.05 to 2.10; p=0.0213).

After 1 year, 43/249 (17.3%) students who had had a negative TST presented themselves for re-testing. Seven individuals were not considered in this analysis because they had been revaccinated after undergoing the TST in the previous year. Seven of 36 (16.3%) re-tested individuals were considered to be non-compliant as they did not return for the test reading. Three of 36 (8.3%) had a positive TST after 1 year (recent converters), but none attended the scheduled medical consultation with a specialist. However, we cannot dismiss the possibility that these individuals may have sought medical advice elsewhere.

In contrast to these results, the data collected with the Biosafety questionnaire revealed a reasonable level of knowledge about health surveillance and preventive measures recommended for minimising risk of exposure to infectious agents. Seventy students (25 male) completed the questionnaire and all considered it was important to discuss Biosafety during their university courses. The great majority recognised that exposure to infectious diseases is one of the risks of working in healthcare, and that Biosafety measures are important to minimise this risk. However, two of the students stated that work in healthcare does not involve risk. Thirty-nine reported knowing the principles of Biosafety applicable to their future profession. They reported that such information was acquired during classes, lectures and extra-curricular courses offered by universities and other institutions, and also from the media, healthcare workers or family.

Students attending courses at the public university were more often non-compliant than students from the private university (OR 1.66, 95% CI 1.28 to 2.14; p=0.0001). This non-compliance was positively associated with attending the course on medicine (OR 2.63, 95% CI 1.76 to 3.93; $p=5.147\times10^{-7}$) and negatively associated with attending the course on pharmacy (OR 0.40, 95% CI 0.26 to 0.62; $p=1.071\times10^{-5}$).

Nursing students had higher non-compliance with the first application (OR 10.58, 95% CI 1.77 to 73.1; p=0.0043) and with the first reading (OR 2.13, 95% CI 1.31 to 3.39; p=0.0016). Medical students were less compliant with the second application (OR 1.89, 95% CI 1.36 to 2.64; $p=9.288\times10^{-5}$). On the other hand, physiotherapy students were more likely to attend the second application when required (OR 0.26, 95% CI 0.13 to 0.50; $p=4.888\times10^{-6}$) but were less likely to attend the

Table 2 Non-compliance with different phases of the tuberculin skin test among healthcare students from Salvador, Bahia, Brazil, 2004–2008

Study population	First application, n/N (%)	First reading, n/N (%)	Second application, n/N (%)	Second reading, n/N (%)
Course				
Medicine	0/626 (0)	86/626 (13.7)	170/352 (48.3)	14/182 (7.7)
Physiotherapy	2/130 (1.5)	14/128 (10.9)	13/75 (17.3)	15/62 (24.2)
Nursing	4/133 (3.0)	30/129 (23.3)	27/63 (42.9)	3/36 (8.3)
Pharmacy	0/132 (0)	14/132 (10.6)	22/81 (27.2)	4/59 (6.8)
Nutrition	0/72 (0)	7/72 (9.7)	21/46 (45.7)	3/25 (12.0)
Phonoaudiology	0/43 (0)	6/43 (14.0)	12/22 (54.5)	1/10 (10.0)
Dentistry	1/28 (3.6)	1/27 (3.7)	5/16 (31.3)	4/11 (36.4)
University				
Public	5/564 (0.9)	97/559 (17.4)	138/318 (43.4)	25/180 (13.9)
Private	2/600 (0.3)	61/598 (10.2)	132/337 (39.2)	19/205 (9.3)
Age (years)				
≤Median (19 years)	1/621 (0.2)	75/620 (12.1)	132/349 (37.8)	27/217 (12.4)
>Median (19 years)	6/542 (1.1)	83/538 (15.4)	138/306 (45.1)	17/168 (10.1)
Unknown or no answer	0/1 (0)	0/0 (0)	0/0 (0)	0/0 (0)
Gender				
Male	0/422 (0)	71/422 (16.8)	99/207 (47.8)	17/108 (15.7)
Female	7/742 (0.9)	87/735 (11.8)	171/448 (38.2)	27/277 (9.7)
Family income (in MW*)				
≤5	1/217 (0.5)	24/216 (11.1)	47/129 (36.4)	7/82 (8.5)
>5	5/903 (0.6)	128/898 (14.3)	209/502 (41.6)	35/293 (11.9)
Unknown or no answer	1/44 (2.3)	6/43 (14.0)	14/24 (58.3)	2/10 (20.0)
BCG vaccination				
Yes	5/874 (0.6)	121/869 (13.9)	200/484 (41.3)	31/284 (10.9)
No	0/33 (0)	5/33 (15.1)	16/22 (72.7)	2/6 (33.3)
Unknown or no answer	2/257 (0.8)	32/255 (12.5)	54/149 (36.2)	11/95 (11.6)
Known contact with a patient with tuberculosis				
Yes				
Close contact (family or household)	0/66 (0)	15/66 (22.7)	14/32 (43.8)	2/18 (11.1)
Other	0/59 (0)	7/59 (11.9)	18/32 (56.2)	2/14 (14.3)
No	7/1017 (0.7)	134/1010 (13.3)	232/578 (40.1)	39/346 (11.3)
Unknown or no answer	0/22 (0)	2/22 (9.1)	6/13 (46.2)	1/7 (14.3)
Previous diagnosis of tuberculosis				
Yes	0/1 (0)	0/1 (0)	0/0 (0)	0/0 (0)
No	7/1151 (0.6)	158/1144 (13.8)	265/646 (41.0)	44/381 (11.5)
Unknown or no answer	0/12 (0)	0/12 (0)	5/9 (55.6)	0/4 (0)

*MW, minimum wage (>5 corresponds to the top half of the economic classification system adopted by Brazilian government agencies[17]).

second reading (OR 3.22, 95% CI 1.49 to 6.77; p=0.0016). Students from the public university were less likely to attend the first reading of the test (OR 1.85, 95% CI 1.29 to 2.65; p=0.0004).

Missing the first or second test application (NC1) was associated with being a medical student (OR 1.50, 95% CI 1.13 to 2.00; p=0.0038), being a physiotherapy student (OR 0.38, 95% CI 0.20 to 0.68; p=0.0003), having received BCG vaccination (OR 0.33, 95% CI 0.15 to 0.70; p=0.0029) and age above the median (OR 1.33, 95% CI 1.00 to 1.76; p=0.0453). The multivariate models constructed to assess NC1 are listed in table 3.

Medical students with a family income of ≤5 MW were slightly protected against NC1, but were more likely to be non-compliant when family income was >5 MW. In this last group, 'reporting previous BCG vaccination' was protective and having 'age above the median' exacerbated NC1. Physiotherapy students were protected against NC1 only if family income was >5 MW, and the association of 'reporting previous BCG vaccination' and 'age above the median' with NC1 was similar to that described above for medical students with a family income of >5 MW.

Absence from the first or second reading (NC2) was associated with attending a public university (OR 1.79, 95% CI 1.30 to 2.48; p=0.0002) and male gender (OR 1.45, 95% CI 1.05 to 2.00; p=0.0195). The multivariate models constructed to assess NC2 are listed in table 4. 'Attending a public university' was not relevant for this type of non-compliance for individuals with a family income of ≤5 MW, but was highly associated with NC2 for individuals with a family income of >5 MW. Gender had a marginal, non-significant effect but its inclusion in the model led to a lower Akaike information criterion.

Table 3 Factors associated with NC1 among healthcare students from Salvador, Bahia, Brazil, 2004–2008

	Crude OR (CI 95%)	Adjusted OR (CI 95%)	OR difference (%)	p Value†
Model 1: income ≤5 MW*				
Being a medical student	0.60 (0.25 to 1.34)	0.39 (0.11 to 1.08)	−35.0	0.0989
Reported BCG vaccination	0.50 (0.09 to 3.69)	0.52 (0.09 to 3.88)	−4.0	0.4598
Model 2: income >5 MW				
Being a medical student	1.70 (1.23 to 2.38)	1.64 (1.14 to 2.40)	−3.5	0.00913
Reported BCG vaccination	0.27 (0.12 to 0.58)	0.28 (0.12 to 0.62)	3.5	0.00179
Age above the median	1.57 (1.15 to 2.13)	1.52 (1.07 to 2.16)	−3.3	0.01796
Model 3: income ≤5 MW				
Being a physiotherapy student	1.06 (0.23 to 3.64)	1.16 (0.17 to 5.10)	9.0	0.856
Reported BCG vaccination	0.50 (0.09 to 3.69)	0.49 (0.09 to 3.67)	−2.0	0.425
Model 4: income >5 MW				
Being a physiotherapy student	0.35 (0.18 to 0.62)	0.41 (0.20 to 0.79)	17.1	0.01249
Reported BCG vaccination	0.27 (0.12 to 0.58)	0.28 (0.12 to 0.63)	3.5	0.00187
Age above the median	1.57 (1.15 to 2.13)	1.40 (0.99 to 1.99)	−10.8	0.05751

*MW, minimum wage (>5 corresponds to the top half of the economic classification system adopted by Brazilian government agencies[17]).
†Significance of association between each variable and NC1 (failure to attend the first or second tuberculin skin test application) in the multivariate multiple regression model.

DISCUSSION

We have examined possible associations between demographic and socio-economic characteristics, as well as choice of study, self-reported BCG vaccination status, history of contact with a TB patient or previous diagnosis of active TB, and loss to follow-up during the TST. We investigated whether differences in these characteristics among groups influenced non-compliance with the test and revealed distinct patterns of risk awareness and self-care given the perception of risk.

The low compliance with the test found in this study was comparable to the results of other studies among students[20 21] and health professionals.[10 13 14] Even when the test is performed in healthcare professionals' place of work, there is a significant rate of non-compliance.[13] Few authors have suggested possible reasons for TST non-compliance, although it is frequently calculated.[4] Sherman and Shimoda comment that the reasons given by staff for missing the TST range from lack of time and forgetting to judging the test not to be personally relevant.[14]

The demographic, socio-economic and other individual characteristics of the test subjects are largely ignored when discussing non-compliance. Few studies report any concern regarding these potential risk factors. Kayanja *et al* show that the demographic and risk-associated characteristics of a non-compliant group were similar to those of compliant individuals,[22] but Silva *et al* show that non-compliant participants were more likely to belong to families with higher income.[20]

Our studied population consisted of students in the first year of healthcare related university courses, who therefore had minimum contact with patients. Nevertheless, we identified one individual with a previous history of TB. Volunteers reporting previous contact with a TB patient did not show higher rates of compliance. Likewise, individuals who claimed that they had not received the BCG vaccination (the only one currently available against TB) did not have higher compliance rates. Instead, report of non-vaccination was significantly associated with non-compliance in the second step of the test, in both the bivariate and the multivariate analyses. Therefore, being potentially at increased risk of TB infection/disease does not seem to lead to preventive action by these individuals.

In accordance with our findings, Trueba *et al* show that the great majority of informed patients and healthcare professionals potentially in contact with a worker

Table 4 Factors associated with NC2 among healthcare students from Salvador, Bahia, Brazil, 2004–2008

	Crude OR (CI 95%)	Adjusted OR (CI 95%)	OR difference (%)	p Value†
Model 1: income ≤5 MW*				
Enrolled in a public university	0.80 (0.32 to 2.30)	0.84 (0.33 to 2.43)	5.0	0.725451
Male gender	1.86 (0.84 to 4.05)	1.85 (0.83 to 4.02)	−0.5	0.125426
Model 2: income >5 MW				
Enrolled in at a public university	2.34 (1.66 to 3.32)	2.39 (1.69 to 3.39)	2.1	8.16×10^{-7}
Male gender	1.27 (0.90 to 1.78)	1.34 (0.94 to 1.90)	5.5	0.099

*MW, minimum wage (>5 corresponds to the half top of the economic classification system adopted by Brazilian government agencies[17]).
†Significance of association between each variable and NC2 (failure to attend the first or second tuberculin skin test reading) in the multivariate multiple regression model.

diagnosed with active TB missed further medical evaluation of possible TB infection.[23] Frequently, the professionals who miss TST evaluations are those potentially with most contact with individuals with TB. We must emphasise that some individuals who completed all steps of the test, including the re-evaluation after 1 year, and were identified as recent converters (indicative of recent infection with *M tuberculosis*), did not take up the offer of an appointment to discuss chemoprophylaxis.

In contrast with these results, the majority of study subjects recognised that work in the healthcare area involves risk of exposure to infectious diseases such as TB. They believed that risk minimisation procedures should be observed, with measures ranging from specific Biosafety measures to care with personal health, including immunisation and periodic monitoring. However, this perception does not translate into action for unknown reasons not specifically addressed in this study. A similar dissociation between knowledge of the disease and TB infection among university students has also been shown,[21] reinforcing the need for interventions that bridge the gap between risk awareness and compliance with Biosafety measures in this population.

Our study reveals that the attitudes of the studied groups towards monitoring are associated with socioeconomic characteristics, with the type of university and course attended, and with age, and are thus probably related to common cultural or psychological factors that may influence opinions regarding the test. Indeed, higher family income, one of the characteristics studied, has been found to predispose to non-compliance with test administration (NC1) among medical students, while favouring compliance among physiotherapy students, revealing a group effect. We do not believe the same results would necessarily be found in other populations, which may differ from that studied here in terms of culture and risk perception. We believe, however, that group effects similar to those described here can occur in various settings and may adversely affect the efficacy of Biosafety programs intended to prevent disease dissemination, even in populations with high access to relevant information.

It is worth emphasising that the high non-compliance rate of >40% observed here, raises great concern regarding the efficacy of disease control measures. In fact, if only 60% of populations at risk are efficiently targeted by control programs, effects on disease transmission will be very limited.

The study team noticed that students commented that they disliked the discomfort caused by the injection during the test. This important psychological factor may contribute to non-compliance. It is worth mentioning that more modern tests, such as the interferon-γ release assays, shown to be more accurate than and potential substitutes for the TST,[24] also involve puncture for blood sample collection.

It is also possible that the distinct groups hold different values and beliefs at variance with the scientific facts of TB infection and progression to disease, precluding these individuals from considering themselves exposed to risk or needing monitoring to protect their health.[25]

This study is limited by the fact that all information collected was self-reported, except for the frequency of non-compliance and the TST induration results, and by the fact that it was conducted in the context of an LTBI survey which was not specifically designed to investigate non-compliance.

Our work highlights the fact that the reasons for non-compliance are poorly understood and may determine the success or failure of nosocomial TB infection monitoring programs. Recognition of these factors may lead to more efficient Biosafety strategies aimed at minimising TB dissemination.

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Contributors All authors actively participated in analysis of the research results. SSR, JMM, CMCM, SA and TB were responsible for study design. SSR, JMM, ESO, JSR, ECL, AEM Jr, SA and TB participated in field work, in the logistics and in managing the administration of the tuberculin skin test and the questionnaires. SSR, JMM, ESO, JSR, ECL, AEM Jr, CMCM, SA and TB also participated in the training of study monitors. ESO, JSR, ECL, AEM Jr, CMCM and TB participated in the creation and management of the database. SSR, CMCM, AA and TB were responsible for the statistical analysis and writing of the manuscript.

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