

Risk Assessment of Tuberculosis Laboratories and Biosafety Practices among Laboratory Health Workers in Two Selected States in Nigeria

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ABSTRACT

Background: Occupational tuberculosis among mycobacteriology laboratory workers has received insufficient attention especially in countries with high burden of tuberculosis despite the associated greater risk than the general population. The aim of the study was to conduct a risk assessment of tuberculosis (TB) laboratories and biosafety Practices among laboratory health workers.

Method: A descriptive study conducted among the laboratory health workers involved primarily in the diagnosis of tuberculosis (TB) in two selected states in Nigeria. A semi-structured questionnaire based on tuberculosis laboratory procedure risk assessment was self-administered by consenting laboratory workers. Data obtained were based on the degree of exposure, viability of bacilli, aerosol generation, laboratory configuration, typology and fitness of the staff to work in the TB laboratory. Risk assessment of tuberculosis (TB) laboratories and biosafety practices was determined by these sets of questions and categorized into low, middle and high risk.

Results: Fifty-eight (58) of the 64 laboratory health workers participated in the study. Their average age was 38.8 ± 7.6 years and male to female ratio of 1 to 1.4 and 82.7% had worked in the TB laboratory for

less than 10 years. The calculated risk for occupational TB was low 55(94.8%) and moderate 3(5.2%) without any of the respondents having high risk. With regards to laboratory practices, majority of the respondents (91.4%) did not reuse slides for smear staining, 81.0% admitted that the laboratories were well-ventilated and 75% regarded their laboratories safe to work. However, pre-employment screening for TB, HIV, diabetes mellitus, and kidney disease was done in 3(5.2%), 7(12.1%), 2(3.4%) and 1(1.7%) respectively.

Conclusion: The result of this study shows that the risk of laboratory health workers exposure to tuberculosis (TB) and potential hazard is low, however more attention be given to infection control policies and pre-employment screening for TB.

INTRODUCTION

The magnitude of occupational exposure to tuberculosis has increased due to a wide range of procedures performed by healthcare workers (HCWs), especially among those working in high tuberculosis (TB) burdened countries.¹ With the risk of developing tuberculosis among laboratory workers estimated at 3 to 9 times higher than the general population, this requires conscientious review of laboratory practice and strict implementation of infection control measures.²⁻⁴ Regardless of the countries TB incidence, this

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recognized occupational hazard particularly in health facilities attending to high number of TB cases is often neglected.^{1,5}

Furthermore, the greater risk of occupational TB among laboratory health workers in low- and middle-income countries (LMIC) is reported to result from the deficiencies in the infection control practices.^{6, 7} Hence, the need for continuous risk assessment and review of laboratory practices to ensure safe working environment which should complement other risk management processes in the laboratory.^{6, 8, 9} Most resource limited countries use direct sputum smear microscopy in the diagnosis of tuberculosis which potentially exposes HCWs to aerosol generation.^{10,11}

The majority of mycobacterial laboratories in Nigeria operate at biosafety levels 1&2 using the four-tier classification system of biosafety or American Thoracic Society level I, where acid fast bacilli (AFB) smears for microscopic examination are routinely done but mycobacterial culture, drug-susceptibility and molecular testing are referred to zonal laboratories.⁸ The decision on the most appropriate biosafety for the different laboratories is based on the regular risk assessment considering the level of exposure during procedures, compliance with standard operating procedures and capability of the laboratory worker.

Following the recommended risk assessment by the World Health Organization, the probability of infectious aerosols generation and likelihood of a potential hazard was adopted in the classification into three levels of risk namely low, moderate and high risk.¹² Several of the direct sputum-smear microscopy laboratories in LMIC are performed in single-room and understaffed with personnel who process a large number of specimens as their daily routine.¹² Considering the manipulation of TB specimen for direct smear microscopy which entails killing the mycobacteria, this procedure is regarded as one with low risk.¹³ However, it is imperative to review the risk in our practice and make appropriate recommendations.

Although there are a few studies elucidating occupational TB in Nigeria, and the prevalence of occupational TB ranged from 1.5% to 3.3 %. To the best of our knowledge, no study has evaluated the level of risk and laboratory practices among mycobacteriology laboratory workers.^{14,15} The objectives of this study were to conduct a risk assessment of tuberculosis (TB) laboratories and biosafety laboratory practices among mycobacteriology laboratory workers in two selected states in Nigeria.

METHODS AND MATERIALS

Study design: This was a descriptive study among mycobacteriology laboratory workers in two selected states in Nigeria. All consenting staff in centers involved in the diagnosis of TB was recruited for this study.

Study setting: This study was conducted in Nigeria, which ranks 10th among the 22 high TB burden countries.¹⁶ Nigeria has an estimated TB incidence of 322 per 100,000 populations and the fourth highest annual prevalence in Africa.¹⁶⁻¹⁷ There are 1,025 facilities with microscopes for TB diagnosis and the AFB laboratory to population is 1 to 149,000.¹⁶ The number of TB cases notified in the two selected states (Kwara and Ekiti states) in 2010 were less than 1,000 being the lowest recorded in the country.¹⁸ Estimated population of Nigeria was 182.2 million people in 2015 with an annual growth rate of 3.5%. The investigators selected two states in two of the six geopolitical zones for ease of coordination.

Sample selection: The respondents were recruited from forty- four laboratories categorized involved in direct sputum smear microscopy (biosafety levels 1 and 2) by non-probability consecutive recruitment. All consenting laboratory staff have worked continuously in a mycobacteriology laboratory for at least one year. Other laboratory staff who were not directly involved in the laboratory diagnosis of mycobacterium tuberculosis were excluded.

Data collection: Pretested questionnaire was administered by two research assistants who were trained by the principal investigator. The body mass index was calculated from the workers' height (in meter) and weight (in kg) which was expressed in Kg/m². A semi-structured questionnaire was developed based on the World Health Organization expert information in the tuberculosis laboratory biosafety manual and literature search.^{10, 11, 19} The following information in different domains was obtained using this instrument to highlight: socio-demographic characteristics, degree of exposure, viability of bacilli, aerosol generation, laboratory configuration, typology and fitness of the laboratory staff.

The questions related to the degree of exposure included the numbers of daily positive stained slides by the HCWs, sputum production by the patients in the laboratory and cross ventilation in the laboratory. On the other hand, the viability of the bacilli was assessed procedure of heat fixing of smear before complete air drying by the laboratory worker, process of disinfection of contaminated material and laundry of laboratory coat with house wear. We assessed laboratory configuration by the self-reporting by HCWs of running water, availability of separate administrative area and incinerator close to laboratory. Questions on the generation of aerosol were based on the recycling of wire loop and air drying of slides on the table. Finally, the typology and fitness of the laboratory staff was based on training on laboratory safety, use of personal protective equipment and eating/drinking or use of phone in the laboratory.

The responses to the questions were graded as minimum and maximum scores per question of 0 and 1 respectively. This was further categorized based on the total percentage score into low, moderate and high based on the percentage score and the WHO safety manual criteria; less than 50%, 50 to 70% and above 70% respectively.¹¹ The risk level refers to how likely it is that someone in the laboratory will become infected with TB as a result

of procedures performed in the laboratory. Low risk is when there is a low risk of generating infectious aerosols from specimens; low concentration of infectious particles. Moderate risk is when there is a moderate risk of generating infectious aerosols from specimens; low concentration of infectious particles. High risk is when there is high risk of generating infectious aerosols from specimens; high concentration of infectious particle.

Data analysis: The obtained data was analyzed using Statistical Package for Social Sciences (SPSS) version 20 (SPSS Inc., Chicago, IL., USA). Descriptive statistics was used to summarize the general characteristics of the respondents. Continuous variables were reported as mean while categorical variables as frequencies.

Ethical consideration: The study was approved by the ethics and research committee of the Ekiti State University Teaching Hospital, Ado-Ekiti. All respondents gave written consent to participate in the study.

RESULTS

General characteristics of respondents

A total of 64 laboratory workers who were involved in diagnosis of *Mycobacterium tuberculosis* in the two selected states were informed about the study. Fifty-eight of them agreed to participate and completed the questionnaire (response rate of 90%). They were relatively young group with an average age of 38.81±7.62 years (ranging from 27 to 58 years). A slight female preponderance was observed as the male to female ratio was 1 to 1.4. All respondents were non-smokers while 1.7% drank alcoholic drinks (average of 10 units per week).

Risk categorization

The calculated risk and categorization into low, moderate and high risk revealed that majority of the respondents had low risk (94.8%) while the remaining had moderate risk (5.2%) as shown in figure 1.

Reported Laboratory practice and Biosafety by respondents

The median number of slides for sputum smear stained by the respondents was 8 slides per day with interquartile range (IQR of 5-60) and median number of positive slides for *Mycobacterium tuberculosis* was 2 slides per day with interquartile range (IQR of 1-20). Majority of the respondents (91.4%) did not reuse slides for smear staining. Sputum smear was done by 38.2% respondents for patients who were discovered eventually to have drug resistant tuberculosis.

Majority of the respondents (81.0%) admitted that the laboratories were well-ventilated however, 31% advocated for the provision of additional biosafety measures like biosafety cabinets (22%), respirator (16.7%), and disposable protective wears (11%) to enhance infection control measures. About three quarter of the respondents regarded their laboratories safe to work and the majority (94.8%) observed standard operating procedure. Pre-employment screening for HIV, TB, diabetes mellitus, renal function and pregnancy test were performed in 12.1%, 5.2%, 3.4%, 1.7% and 2.9% of the respondents respectively. Almost a fifth of the respondents (17.3%) were involved in mycobacteriology laboratory for a period of ten years while themajorities were less than 10 years in employment. Not all respondents had a formal training (67.2%) involving didactic lectures and practical sessions before they commenced work at the mycobacteriology laboratory. Figure 2shows that about a quarter (25.6%) of the staff had any formal TB training in the preceding year.

A substantial number (69%) of mycobacteriology laboratory workers are afraid of contracting the disease and would rather work in other units, if given the opportunity as a majority admitted to a level of risk due to their working in the TB laboratory and one third of the respondents concerned this risk as high.

Table 1: Characteristics of the respondents in the study

Characteristics	N (%)
Age in years	38.81±7.62
Gender	
Male	24(41.4)
Female	34(58.6)
Mean Body mass index(kg/m ²)	25.92±4.17
<18.5kg/m ²	0(0.0)
18.5-24.9kg/m ²	23(39.7)
25.0-29.9kg/m ²	24(41.4)
>30.0kg/m ²	11(19.0)
Education	
Primary	2 (3.4)
Secondary	2(3.4)
Tertiary	54(93.1)
Duration of employment	
Less than 10 years	48(82.7)
10years and above	10(17.3)
Pre-employment screening	
HIV status	7(12.1)
Tuberculosis	3(5.2)
Kidney function	1(1.7)
Screening for Diabetes mellitus	2(3.4)
Pregnancy test	1(2.9)
Median microscopy slides(Q1-Q4) stained per day	8(5-60)

(Q1-Q4)- Interquartile range

Figure 1: Pie chart showing the calculated risk category

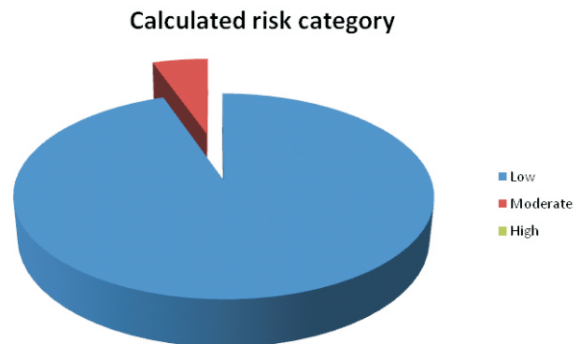
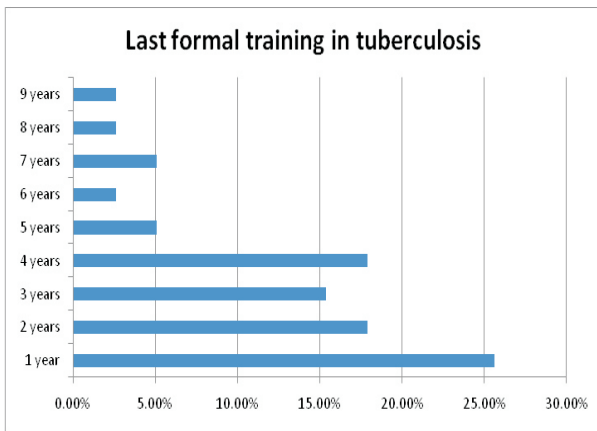


Figure 2: Bar chart showing the last formal training in tuberculosis



DISCUSSION

The result of our study shows that the risk of contracting TB from workplace among mycobacteriology laboratory workers is low. However, more attention is needed in the area of training of laboratory staff, use of personal protective devices and pre-employment screening for tuberculosis as well as associated risk factors. These findings point to an urgent need for the implementation of an integrated occupational tuberculosis control programme into the national guideline.

All the respondents in our study worked in laboratories with biosafety levels 1 and 2 where smear microscopy is performed and are ranked low risk based on the WHO procedural risk evaluation.¹¹ This risk classification is similar to our deduction as the majorities (94.8%) were categorized as low risk and none of the respondents had a high risk of occupational TB. Similarly, a Korean study substantiated that performing sputum smear microscopy poses low risk to HCW compared to drug sensitive testing and other procedures requiring manipulating liquefied sputum specimens.²⁰

Although, a few of the respondents requested the provision of biosafety cabinet as additional infection control measure but evidence shows there is no need for specific facilities and equipment such as safety cabinets to control airflow in smear

microscopy due to the low aerosol generation.^{20,21} In cases of non-adherence to the standard operating procedure while performing smear microscopy, despite the attributed low risk, there could be an increased probability of contracting tuberculosis in such laboratory workers. Our study found that 94.8% of the respondents observed the standard operating procedure which could further account for this low risk among the respondents.

Mycobacteriology laboratory workers are part of the front line workers who suffer the aftermath of a progressive fatal drug sensitive and resistant strain of TB in the hospital environment. This is further established as one in every four slides stained by the respondents were reported smear positive, likewise, one third of the respondents had been exposed, unknowingly, to specimen of patients that turned out to be drug resistant TB.^{6,32} This calls for the need to strengthen the major microscopy centers, especially those with high specimen load and incidence of resistant TB, to accommodate primary containment facility as mitigation and control measures in the event of a suspected resistant case.

An operational pre-employment screening of all healthcare workers for TB using a newer technique like interferon-gamma release assays (IGRA) is often employed in most developed countries; however, our study reported negligible screening for tuberculosis in this group of HCWs.^{22, 23} Although, there is limited data on the use of this newer technique in Nigeria, as TST and Chest Xray readings are often used for this screening in our setting and it often overestimates the prevalence of LTBI.^{22, 24-26} The non-utilization of this newer technique like Interferon-gamma release assays (IGRA) may be attributed to the high cost of such tests. Notwithstanding, a baseline screening is fundamental and should be institutionalized as an infection control measure in all healthcare facilities.

In our study, only 21.1% of the mycobacteriology laboratory workers had pre-employment HIV screening despite HIV being a major risk factor for TB among HCWs. In a study conducted in a tertiary

institution in south-south Nigeria, 3.1% HIV sero prevalence rate was reported during pre-employment screening of HCWs.²⁷ Although HIV screening is voluntary, it is important for HCWs to know their HIV status as those who are positive could be commenced on antiretroviral therapy as well as isoniazid preventive therapy, if no evidence of active TB and such could be reassigned to other units where the risk of exposure to TB is minimal.^{28,29}

Similarly, diabetes mellitus and chronic kidney disease are recognized risk factors for TB with both conditions also having a rapid rise in prevalence among the Nigerian populace.^{30, 31} Unfortunately, very few of the respondents had pre-employment screening for these important risk factors. This could probably be due to poverty as the level of unemployment is high in Nigeria and newly employed find it difficult to pay for investigations required during the pre-employment screening exercise.^{26,32} In addition, the low level of awareness of the risk factors of TB like HIV infection, alcohol consumption, diabetes mellitus and chronic kidney disease among Nigerians could also account for it.³³

This study has given a snapshot of the level of occupational TB risk among laboratory workers in two regions in the country. However, it cannot be generalized to the entire country, as future studies should be conducted to involve more centers in the country, especially regions with higher prevalence of tuberculosis.

CONCLUSION

In conclusion, the results of our study has shown the low risk of occupational TB in laboratories workers however, adhering strictly to the standard operating procedure and infection control policies will further reduce such associated risk. Likewise, the implementation of appropriate tuberculosis IC measures in every healthcare facility and ensuring regular training of staff on the infection and biosafety measures are crucial to TB elimination. Although general national TB infection control policies are in place, there are no specific

Occupational Health policies and TB infection control that exist in most hospital settings. Therefore, policies implementation of the TB infection control measure will be an important step towards risk reduction in the mycobacteriology laboratory. Furthermore, it is imperative that all healthcare workers should have a proper pre-employment assessment and routine screening for proper placement, prompt diagnosis and treatment of TB in a healthcare center for effective control of TB.

COMPETING INTEREST: All authors declare no competing interests

AUTHORS' CONTRIBUTION: AOA was involved in the study concept design, analysis, drafting and revision of manuscript. OOD was involved in the analysis and revision of manuscript. JOF was involved in the revision of manuscript,

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