THE EFFECTIVENESS OF ACID FAST BACILLI (AFB) SMEAR MICROSCOPY TRAINING IN PERFORMANCE IMPROVEMENT AMONG NIGERIAN MILITARY HOSPITAL TB LABORATORY PERSONNEL: ANALYSIS OF PRE AND POST TRAINING EVALUATION SCORES

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SUMMARY

OBJECTIVE

This study is planned to determine the effectiveness of AFB smears microscopy training and refresher training on the performance of TB laboratory personnel working in the Nigerian Military Hospital.

BACKGROUND

With an estimated 9.4 million new cases globally, tuberculosis (TB) continues to be a major public health concern[1]. Eighty percent of all cases worldwide occur in 22 high-burdens, mainly resource-poor settings of which Nigeria ranked 13th. This devastating impact of tuberculosis on vulnerable populations is also driven by its deadly synergy with HIV. Therefore, building capacity and enhancing universal access to rapid and accurate laboratory diagnostics are necessary to control TB and HIV-TB co-infections in resource-limited countries[2]. In low income countries (Nigeria inclusive), Ziehl-Neelsen sputum smear microscopy is the only cost-effective tool for diagnosis and monitoring of patients on treatment[3]. In order to have efficient and reliable AFB microscopy centres, it is very necessary to have continuous refresher training for laboratory professionals and strong External Quality Assessment (EQA) system. However, very little data exists as to the effect of in-service training on performance of laboratory personnel in Nigeria.

METHODS

A cross-sectional retrospective study was conducted to appraise theoretical and practical performance of TB Laboratory personnel drawn from various Nigerian Military hospitals supported by the joint partnership of Nigerian Ministry of Defence (NMOD)/United States Department of Defense Walter Reed Program-Nigeria (USDOD WRPN), before and after AFB microscopy training. Theoretical assessment was based on standard questions while practical assessment was based on smear reading of 10 standard slides. Data generated from four (4) rounds of a five days AFB Smear Microscopy training at NTBLTC, Zaria, Kaduna State, Nigeria between 2011 and 2013 was retrospectively collated and analyzed using SPSS 16.0 statistical software.

RESULT

The pre-training mean score of the theoretical knowledge and practical skills were 64.3% and 64.5%, respectively. The post training mean scores were 83.6% and 85.3% for theoretical knowledge and practical skills, respectively. The increase in mean score of both theoretical and practical assessment was statistically significant ($p<0.0001$). Post training mean score of theoretical knowledge was higher among diploma holders trainees than the BSc degree counter parts ($p=0.001$). The mean scores on practice before and after training were dependent on participation in previous AFB microscopy trainings ($p<0.0001$). Proportions of participants with both major and minor errors were found to decrease after they were trained. Trainees who have had previous training were found to commit less error than those who have never participated in previous training ($p<0.0001$).

CONCLUSIONS

This study established that training improved theoretical and practical performance of Medical Laboratory personnel. Training and continuous training irrespective of lab professional's qualification, service status and service year and sustainable EQA are highly recommended to ensure quality of AFB microscopy services in all NMOD/USDOD supported health facilities across the country.

INTRODUCTION/BACKGROUND

Tuberculosis (TB) remains a major global health problem. There were 8.6 million new TB cases in 2012 and 1.3 million TB deaths[1]. In 2012, there were an estimated 2.9 million cases and 410 000 TB deaths among women, as well as an estimated 530 000 cases and 74 000 deaths among children[1].

At least one-third of the 35.3 million people living with HIV worldwide are infected with latent TB[2]. Around 75% of these people live in sub-Saharan Africa (Nigeria inclusive).[2] TB is the leading cause of death among people living with HIV, accounting for one in five HIV-related

deaths[3]. In 2012, some 320,000 people died of HIV-associated TB[2]. People living with HIV are facing emerging threats of drug-resistant TB such as multi-drug resistant (MDR-TB) and extensively drug resistant TB (XDR-TB) [2].

Nigeria ranks 13th nation, among the 22 high-burden TB countries in the world. [2] WHO estimates that 90,305 new cases of all forms of TB occurred in Nigeria as at 2012. There were an estimated 161,000 prevalent cases of TB in 2012. 97,853 TB cases were notified in 2012 with 52,901 (59%) cases as new smear positives, and a case detection rate of 51%. Also, there is estimated range of 1800-3400 MDR-TB cases among notified pulmonary TB cases in Nigeria as at the end of 2012. The main goal of Nigeria's TB program is to halve the TB prevalence and death rates by 2015[4].

In low income countries, especially those with the highest burden of TB, Ziehl-Neelsen sputum smear microscopy is the only cost-effective tool for diagnosing patients with infectious tuberculosis and to monitor their progress in treatment[5]. It yields timely results but the sensitivity is low as compared fluorescent microscopy and culture [6, 7.]

External Quality Assessment (EQA) which consists of blind rechecking, panel/proficiency testing and onsite supervision is important to identify errors so that corrective actions can be taken to improve the overall performances of microscopy centres [8]. Training of TB Laboratory personnel along with sustainable EQA is important to improve the technical competency of laboratory professionals in every aspects of AFB microscopy [9, 10]. The implementation of EQA for microscopy has the advantage not only of strengthening laboratory networks but of improving diagnostic quality[11].

Studies in Africa and other different parts of the world have shown that effective and sustainable EQA and training programs are significant in improving the performance of AFB microscopy facilities [12, 13, 14].

In Nigeria, multiple trainings have been conducted but most of the training data were not analyzed to see the overall effect of training on performance of the Laboratory personnel that can be measured in terms of scores on theoretical and practical assessments. Therefore, the aim of this study was to critically appraise the performance of laboratory personnel before and after they were trained in AFB microscopy in Nigeria, among the TB Laboratory personnel working in Military facilities across the country.

The United States Department of Defense Walter Reed Program-Nigeria (USDOD WRP-N) and the Nigerian Ministry of Defense/Emergency Plan Implementation Committee (NMOD/EPIC) has been implementing the PEPFAR program in Nigeria, collaboratively in various military hospitals since 2005.

The implementation plan included strengthening and scaling–up TB laboratory services to ensure quality TB laboratory diagnosis in all NMOD/DOD supported sites laboratories across the country.

AFB (TB) smear microscopy training was conducted at various times to address the gaps/deficiencies observed in the reporting patterns of AFB microscopists working in NMOD/DOD-supported laboratories among other deficiencies noted during the previously organized AFB EQA panel testing and on-sites blinded re-checking exercises on some selected TB laboratories conducted recently. It was expected that the training would also address laboratory staff capacity gaps created as a result of staff attrition and transfers.

Finally, to ensure capacity development along the nationally set standards, the training was conducted always at the National TB and Leprosy Training Centre, Saye-Zaria, Kaduna State using the National AFB training curriculum as well as experienced national trainers.

SIGNIFICANCE OF THE STUDY

Despite many AFB microscopy trainings conducted in this region, analysis of training data is not commonly carried out or utilised in Nigeria and most other countries. Analysis of training data is important as it can provide information on performance of trainees so that appropriate interventions can be established. Therefore the outcome of this study will alert trainers to plan for enhanced quality of AFB microscopy trainings and policy makers in tuberculosis control program to give attention to continuous on job AFB microscopy training towards enhanced case detection and better control of tuberculosis.

METHODOLOGY

Retrospective investigation was conducted in May2014 to assess effectiveness of AFB microscopy training on performance of TB laboratory personnel. Data on four (4) rounds of a five days training for 109 trainees on AFB microscopy between 2009 and 2003 were collated and analyzed. All the participants for AFB training used for this study were enrolled at different times in the four (4) rounds of training and their evaluation was based on their score on pre and post training assessment on theory and practical. Both theoretical and practical assessments were scored by the trainers who were senior medical laboratory personnel with at least Master degree in medical laboratory technology and minimum of 5 years of service. The trainers were all competent with wealth of experience and certified with training of trainers (TOT) in AFB microscopy.

Theoretical evaluation was based on pre and post test standard multiple choice questions corrected out of hundred (100%). Evaluation of participants on practical was based on smear reading on a set of 10 stained panel slides that were prepared and graded as per the standard procedure [8]. Each trainee/participant was provided with 10 stained slides and the reading was scored/corrected out of 100 in which 10 point was given for correct reading, 5 point for

Quantification Error (QE) and 0 point for any type of false reading (Low False Positive, High False Positive, Low False Negative or High False Negative) as per the scoring system of proficiency in reading [15].

The overall evaluation system was based on the following table;

Table: 1.Types and Classification of Errors (by WHO, IUALTD and CDC)

Result of Technician	Result of Controller				
	Negative	1-9 AFB/100 f	1+	2+	3+
Negative	correct	LFN	HFN	HFN	HFN
1-9 AFB/100 f	LFP	correct	correct	QE	QE
1+	HFP	correct	correct	correct	QE
2+	HFP	QE	correct	correct	correct
3+	HFP	QE	QE	correct	correct

Correct:	**No errors**	**Types of Errors**
QE	Quantification error	Minor error
LFN	Low False Negative	Minor error
LFP	Low False Positive	Minor error
HFN	High False Negative	Major error
HFP	High False Positive	Major error

SPUTUM SMEAR MICROSCOPY (PANELS) TEST SCORING

- Set of 10 slides, each slide is worth 10 points, total possible score = 100
  - HFP and HFN scores 0
  - LFP, LFN and QE scores 5
  - Passing score = 80 – 90 (determined by NTP)

Using data collection format, participants'/trainees' score on pre and post training theoretical and practical assessments as well as information on their characteristics including sex, qualification, service status, service year, participation in previous training and their facility/health institution level (primary, secondary and tertiary) was collected from the training data base of joint NMOD/USDOD partnership program. Data was entered and analyzed using SPSS statistical soft ware (version 16) at a statistical significance of $p < 0.05$. The mean theoretical and practical scores as well as error types with their rates on smear reading before and after training were determined. Mean score before and after training was compared using paired T test. The effect of trainees' characteristics on their theoretical and practical scores as well as error rates before and after training was statistically tested using logistic regression analysis.

RESULTS

CHARACTERISTICS OF TRAINEES

Out of 109 trainees, 89 (81.6%) were males, 81 (74.3%) with qualification of diploma, 70 (64.2) with military as service status, 69 (63.3) with service year ranging from 0 to 3 years, 64 (58.7) did not participate in similar previous trainings while 14 (12.8), 84 (77.1) and 11 (10.1) were the primary, secondary and tertiary military health institutions level respectively. Analysis of training data has shown that more than half of the trainees enrolled between 2011 and 2013 have not participated in previous trainings (Table 2).

Out of total trainees with qualification of BSc degree, 64% and 25% had service year of 0–3 and 4–7, respectively (Figure 1).

Table 2: Frequency distribution of characteristics of participants/trainees

Characteristics		Frequency n (%)
Sex	Male	89 (81.6)
	Female	20 (18.4)
Qualification	Diploma	81 (74.3)
	Degree	28 (25.7)
Service Status	Military	70 (64.2)
	Civilian	39 (35.8)
Service year	0–3	69 (63.3)
	4–7	21 (19.4)
	8–11	13 (11.9)
	12–15	2 (1.8)
	16 - 19	2 (1.8)
	>=20	2 (1.8)
Previous training	Yes	45 (41.3)
	No	64 (58.7)
Health institution Level	Primary	14 (12.8))
	Secondary	84 (77.1)
	Tertiary	11 (10.1)

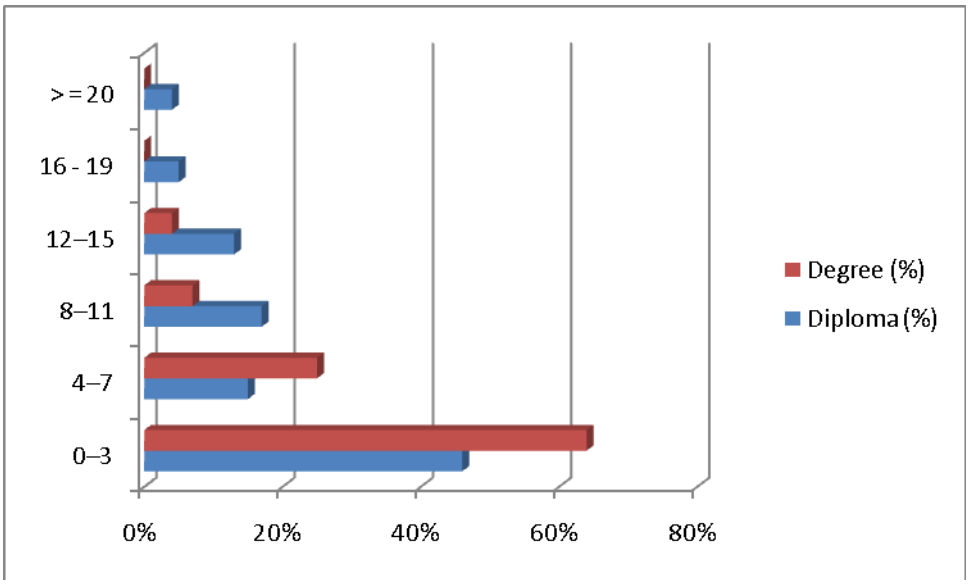

Figure 1: Distribution of trainees by service year and qualification,

THEORETICAL AND PRACTICAL SCORES OF TRAINEES

Analyses of pre training evaluation data have shown that the mean score of the trainees in the theoretical assessment was 64.3% with minimum score of 42%, maximum score of 90%. Pre training practical assessment has shown that the mean, minimum and maximum scores of trainees were 64.5%, 35%, 95%, respectively. Analysis of post training evaluation has shown that the mean, minimum and maximum scores of trainees in theory were 83.6%, 55%, and 100%, respectively. Data on post training evaluation revealed that the mean, minimum and the maximum, scores were 85.3%, 50% and 100%, respectively in practical performance. Post training mean score of trainees in theory and practice was significantly increased ($P < 0.0001$).

THEORETICAL AND PRACTICAL SCORES BY CHARACTERISTICS OF TRAINEES

Trainees' characteristics were investigated to identify their effect on mean score of theoretical knowledge before and after training. The pre training theoretical mean score was not affected by any of the investigated trainees' characteristics but post training assessment has shown that the mean score of theory was higher among diploma holder trainees than the degree counter parts ($p = 0.001$) (Table 3). Pre and post training mean score in practice was not dependent on trainee's sex, qualification and service year ($P > 0.05$). But it was observed that both pre and post training mean scores in practice was higher among trainees who have had previous training than those who have had no such training ($P < 0.0001$).

It was also found that the mean score of practice after training was higher among participants from tertiary health institutions level than the secondary counterparts but with least in primary health institution (P < 0.011) (Table 4).

Table: 3 Pre and post training theoretical mean score on smear reading by different characteristics of participants

Participants' characteristics		Pre training theoretical mean score in %	SD	P-value	Post training theoretical mean score in %	SD	P-value
Sex	Male	59.8	15.3	0.791	83.9	11.6	0.578
	Female	60.6	16.2		85.5	11.9	
Qualification	Diploma	58.8	15.5	0.97	85.5	11.2	0.001*
	Degree	63.7	16.7		80.1	12.3	
Service Status	Military	58.9	15.9	0.879	81.4	11.4	0.001*
	Civilian	61.4	14.5		82.1	11.1	
Service year	0–3	62.5	16	0.887	83.4	11.8	0.874
	4–7	57.8	15.6		85.4	11.3	
	8–11	63.9	10		86.5	11.2	
	12–15	59.5	16.3		88	10.4	
	16-19	61.4	14.5		82.4	11.1	
	> = 20	67.6	11.8		81.4	14.7	
Previous training	Yes	62.5	14.5	0.461	85.2	12.1	0.129
	No	61.1	14.4		83.3	11.4	
Health institution Level	Primary	58.8	15.6	0.126	83.8	11.1	0.354
	Secondary	60.7	13.8		82.8	12.3	
	Tertiary	63.1	12.6		85.2	10.2	

SD=standard deviation, *=statistically significant.

Table: 4 Pre and post training practical mean score on smear reading by different characteristics of participants

Participants' characteristics		Practical pre-training			Practical post- training		
		Mean score in %	SD	P-vale	Mean score in %	SD	P-value
Sex	Male	76.4	12.8	0.386	89.1	10.8	0.986

	Female	79.7	11.6		89.9	11.3	
	Diploma	76.1	12.5		90.3	10.2	
Qualification	Degree	74.7	13.9	0.134	86.2	12.1	0.008*
	0–3	75.8	13.7		88.7	11.3	
	4–7	76.8	12.7		91.8	8.7	
	8–11	72.5	12.5		87.5	11.8	
	2–15	75.5	11.7		90.5	6.2	
	16-19	65.5	14.8		85.5	11.9	
Service year	> = 20	83.2	11.7	0.396	93.8	8.5	0.737
Previous training	Yes	84.7	10		91.9	10.9	
	No	67.9	12.7	<0.0001*	87	10.3	<0.0001*
Health institution Level	Primary	76.3	11.4		88.5	11.3	
	Secondary	79.6	11.6		90.7	8.9	
	Tertiary	80.9	10.6	0.87	91.7	9.1	0.011*

SD=standard deviation, *=statistically significant

TYPE OF ERRORS COMMITTED BY TRAINEES

Pre and post training score analysis on type and error rates has shown that majority of trainees/participants committed quantification error but the percentage of participants with this type of error drastically decrease after they were trained (p = 0.02). Before the training 13.6% of trainees were found to commit minor error of low false negative but after training, the percentage of trainees with this error were found to decrease substantially (p < 0.0001) (Table 4). Similarly, the microscopic reading result of 6.5% of the trainees was found to be high false positive before trainings however after the training only 1.2% of participants were found to commit high false positive result (p = 0.027). Before and after the whole rounds of trainings, it was also observed that 11.4% and 46.5% of trainees respectively, have correctly read all slides (P < 0.0001) (Table 5).

Table: 5 Distribution of participants by microscopic smear reading error type before and after training

Error type	Before training in %	After training in %	p-value
Quantification error	59.5	44.4	0.020*
Low false negative	13.6	2.3	<0.0001*
Low false positive	4.4	2.3	0.649

High false negative	4.6	3.3	0.072
High false positive	6.5	1.2	0.027*
No error	11.4	46.5	<0.0001*

* = statistically significant

ERROR RATES BY TRAINEE'S CHARACTERISTICS

Analysis of effect of trainees' characteristics on error rates was carried out after categorizing all types of errors to one group (error), and correct reading in to no error.

Accordingly, more males (94.4%) than females (85%) were found to commit at least one error in microscopic reading before training, but the difference was not statistically significant (p = 0.179). Except participation in previous training, other trainees' characteristics were also not associated with smear reading errors. Participants who have participated in previous training than those who have not, were found to read all slides without error (p < 0.0001) (Table 6).

Table: 6 Pre and post training error by characteristics of participants

Trainees' characteristics		**Pre training error (n=109)**			**Post training error (n=109)**		
		Yes n(%)	**No n(%)**	**P-value**	**Yes n(%)**	**No n(%)**	**P-value**
		N (%)	**N (%)**		**N (%)**	**N (%)**	
Sex	Male	84(94.4)	5(5.6)	0.179	60(67.4)	29(32.6)	0.064
	Female	17(85)	3(15)		11(55)	9(45)	
Qualification	Diploma	76(93.8)	5(6.2)	0.125	59(72.8)	30(37.1)	0.071
	Degree	24(85.7)	4(14.3)		21(75)	7(25)	
Service status	Military	63(90)	7(10)	0.328	54(77.1)	16(22.9)	0.067
	Civilian	34(78.2)	5(12.8)		27(69.2)	12(30.8)	
Service year	0–3	65(94.2)	4(5.8)	0.492	47(68.1)	22(31.9)	0.28
	4–7	19(90.5)	3(9.5)		13(61.9)	8(38.)	
	8–11	12(92.3)	1(7.7)		8(61.5)	5(38.5)	
	12–15	2(100)	0(0)		1(50.0)	1(50.0)	
	16-19	1(50)	1(50)		0(0)	2(100)	
	>=20	2(100)	0(0)		0(0)	2(100)	
Previous training	Yes	38(84.4)	7(15.6)	<0.0001*	24(53.3)	21(46.7)	<0.0001*
	No	62(96.9)	2(3.1)		51(79.7)	13(20.3)	

Health institution Level	Primary	10(90.9)	1(9.1)		8(72.7)	3(27.3)	
	Secondary	71(81.6)	16(18.4)		62(71.3)	25(28.7)	
	Tertiary	8(72.7)	3(27.3)	0.051	7(63.6)	4(36.4)	0.092

*=statistically significant.

DISCUSSION

Between 2011 and 2013, four (4) rounds of trainings were conducted for 109 laboratory personnel by the joint partnership of NMOD/USDOD program with objective to strengthen AFB microscopy service within the military health facilities. Data on those trainings were retrospectively investigated to measure the effectiveness of training on performance of participants in the form of post test assessment. Most of the participants at these training were diploma graduates with 20 years as maximum service year. Also, those participants with qualification of BSc degree have minimal service years and this may be due to the fact that the BSc degree program in Nigeria started some few decades ago and has now completely replace the faced out Medical Laboratory Diploma program, though majority are still currently working in most of Military health facilities spread across the country. Nearly half of the participants enrolled in the current study have also had similar training before (41.3%).

Training along with other interventions is very important to strengthen AFB microscopy facilities [10]. The purpose of training is to improve the performance of professionals and this requires analysis of training data as it is important for planning. The analysis of the training data has revealed that participants performance have significantly improved, both in theoretical knowledge and practical skills. The mean pre training proficiency of participants on smear reading was found to be 64% but it was increased to 83% after the training. In standard routine panel testing, participants are expected to score a proficiency of 80% in smear reading [15]. Proficiency of the participants was lower than the standard before they were trained but the training impact has made most of them to attain the expected standard score. Investigations in some other countries have also reported similar findings [12, 13]. In addition, training can also motivate, update on new information and facilitate ways to share experience so that laboratory personnel can thrive for better and quality services.

The AFB microscopists in health facilities have different backgrounds in terms of qualification, training, experience and others. It is therefore essential to consider all these characteristics for possible interventions during training as well as utilising analysed training data to the fullest advantage. In this study, post training theoretical performance of laboratory personnel with qualification of BSc degree was lower than the diploma graduates. Ideally, the performance of BSc degree graduates is expected to be better than diploma graduates. The identified difference may be due to non-payment of full attention resulting from over confidence or negative attitudes to training probably exhibited by BSc degree graduates during trainings.

As shown in the pre and post practical analysed data, trainees who have participated in previous similar training have demonstrated better performance than those who have not been previously trained. This finding indicates that training and re-training is important to improve practical performance of TB laboratory personnel. Some other studies have also supported as well as reported the importance of on job training in improving performance and effectiveness of laboratory personnel involved in AFB microscopy [8, 12, 14]. Apart from training, it is also important to implement sustainable EQA program to have efficient AFB microscopy facilities [12]. The post training practical assessment equally shows that participants from tertiary health facilities have performed better than those from secondary and lastly followed by primary health facility (p=0.011). This could be due to the fact that participants from tertiary health institution are better exposed frequent training (new technologies) and hence highly motivated to pay more attention to training than their counterparts from secondary and primary health facilities.

In clinical AFB microscopy, both minor (QE, LFN, and LFP) and major (HFN, HFP) errors occur at a different rates as a result patient management as well as TB control program can be affected depending on the magnitude and type of error. This study has shows higher rate of QE which is comparable with other study in Mexico [12] but study in India has reported higher rate of LFN than QE [14]. This study shows that, significant number of participants had previous similar training, but participants in the study of India were fresh graduates. This probably could be the reason for the identified variation in analysed data.

Proportion of participants who committed false positive (LFP and HFP) and negative (LFN and HFN) errors were significantly reduced after been trained, but these errors are not completely eliminated. Data from other studies [8, 9, 15] have also shown similar finding. This can probably be due to the inherent low sensitivity nature of Ziehl-Neelsen AFB microscopy; these are technical problems which can be address through continuous refresher training and other interventions. In standard EQA, any major error (HFP or HFN) or any HFP with more than three LFN is not acceptable performance, but lower rates of minor error can be accepted only if this does not become recurrent issue. False negative and false positive errors have significant impact on patient management as well as the TB control program unlike the QE case [15]. Therefore, improving the competency of TB Laboratory personnel thorough refresher training, EQA implementation and other interventions are very essential to reduce or completely avoid these types of errors.

In this study, it was observed that participants who have participated in previous similar trainings were found to commit fewer errors than those who had no previous training. These outcomes may indicate the actual performance in the various health facilities. A post training evaluation on impact of AFB microscopy training in Ghana has reported accelerated improvement in the performance of AFB microscopy health facilities [8]. The successive improvement of case detection in the NMOD/USDOD WRPN supported military health facilities from previous 28% to current 46% (unpublished report) indicates the improved performance of AFB microscopy facilities and this could be due to continuous refresher trainings and other interventions.

This study was not without limitations. The main pitfall of this study was the fact that it failed to conduct impact assessment at each health facility where the participants were drawn from after the training on case detection due to current movement restriction (placed by the agency management) as result of recent insurgencies and security threat in northern part of Nigeria.

CONCLUSION AND RECOMMENDATION

In low income and high tuberculosis prevalence countries like Nigeria, sputum smear microscopy is, and is likely to remain for the foreseeable future. It is the only cost-effective tool for diagnosing patients with infectious tuberculosis and to monitor their progress in treatment. But there is urgent call on Microscopist at all level to pay more attention to every details of steps required towards ensuring generation of quality and accurate diagnosis by bearing in mind the possible consequences of wrong or mis-diagnosis in all in our communities. Microscopists at all level must bear in mind that: '*Good Quality Smear Examination makes A Good Quality TB Control Program*'.

The study established and proved that training/re-training has improved theoretical and practical performance of TB laboratory personnel drawn from NMOD/USDOD WRPN supported facilities across Nigeria. Training has reduced minor error (QE, LFN, and LFP) and major error (HFN and HFP) but it has not totally avoided these errors. Pre-placement and continuous training irrespective of laboratory personnel qualification and service year, and sustainable EQA are highly recommended to ensure quality AFB microscopy service.

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