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Assessment of laboratory capacity of public secondary health facilities in performing assay of selected epidemic-prone diseases in Oyo State, Nigeria

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ABSTRACT

This study assessed the capacity of public secondary facility-based laboratories in conducting diagnostic tests for selected epidemic-prone diseases in Oyo State, Nigeria. A descriptive cross-sectional study was conducted in 17 secondary facility-based laboratories in Oyo State. Capacity was assessed on a 100-point scale in which scores were rated low (≤49%), fair (50–79%) and good (≥80%). Diagnostic testing capacity for bacterial meningitis, cholera, and measles was "low" in all the laboratories. The reasons reported for laboratories not conducting diagnostic tests for the selected diseases included inadequate instruments, unavailable reagents, and clinicians' failure to request those diagnostic tests. Laboratory capacity to perform diagnostic tests for the selected diseases was low in Oyo State secondary hospitals. There is a need for the provision of modern instruments and reagents, as well as clinician laboratorian quality assurance programs, to improve diagnostic services relating to the selected diseases.
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1. Introduction

A functional public health laboratory is required to detect, control, and prevent infectious diseases across the globe (Nkengasong 2009; Trevor et al. 2010). While clinical signs often prompt diagnostic testing, laboratory data provide justification to make clinical decision. Treatment of communicable diseases should be based on diagnostic testing, but most times, implementation of treatment is based on clinical symptoms which are nonspecific (Trevor et al. 2010). This practice can lead to inappropriate treatment and unnecessary loss of lives (Petti et al. 2006). Conversely, errors made during laboratory diagnostic testing will affect accuracy of the result. Consequently, physicians can misdiagnose because of the misleading laboratory result (Trevor et al. 2010).

Generally, errors in laboratory diagnosis of infectious diseases are common (Amexo et al. 2004). For instance, in the United States of America, laboratory diagnostic errors are between 6% and 12% (Trevor et al. 2010). In Africa, statistics from the World Health Organization (WHO) suggested that over 90% of malaria cases are misdiagnosed (Trevor et al. 2010). In the sub-Saharan African country of Malawi, 60% of patients were misdiagnosed smear-positive for pulmonary tuberculosis (Petti et al. 2006). In Nigeria, laboratory misdiagnosis of malaria has also yielded false-positive results (Aiyenigba et al. 2017). For instance, a study conducted by researchers in Department of Medicine, University of Lagos, Nigeria, found that correct diagnosis of cerebral malaria was made in 52 patients (46.4%) out of 112 suspected cases, and an incorrect diagnosis of septicemia in 23/112 (20.5%) and meningitis in 17/112 (15.2%) patients (Okubadejo and Danesi 2004). Therefore, misdiagnosis and failure of healthcare providers to make accurate diagnosis before treating a patient remain a concern to public health in Nigeria (Pamela, 2011)

Laboratory misdiagnoses and poor laboratory services can be attributed to the unavailability of diagnostic kit and associated reagents, lack of or outdated equipment; a deficiency of human resources, absence of good policies or strategic plans, and a general poor relationship or discord between clinicians and laboratorians. Likewise, low morale of laboratory staff, cost of diagnostic tests, lack of ongoing laboratorian training programs, and lack of implementing and monitoring internal and external quality control have also been reported (Aiyenigba et al. 2017; Birx et al. 2009; Stuart et al. 2010). Additional weaknesses in the Nigeria laboratory system include inadequate budgeting or funding (Abimiku 2009), unfamiliarity with laboratory safety procedure (Kehinde et al. 2005), illegal practice, and quackery (Charles, 2016).

Nigeria operates a 3-tier (primary, secondary, and tertiary) laboratory system, which is integrated in the healthcare system. Some of the laboratories are hospital-based; others stand alone in association with different hospitals. National guidelines are in place for each level, including infrastructure requirements, operations, and specific analyte

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testing (MLSCN, 2012). Laboratory diagnostic test referrals in Nigeria also follow the order of the tier system except in situations where specimens need to be sent to a regional or centralized reference laboratory.

Although these reference laboratories are established for advanced diagnostic testing and confirmation of outbreaks of some specific communicable/epidemic-prone diseases, the capacity at tier-2 or secondary laboratories still requires strengthening to meet the demand of local health authorities especially in identifying an emerging outbreak. Tier-2 laboratories' capacity also requires strengthening to avoid unnecessary referrals for diagnostic test (Akande 2004). However, the documentation of capacities of such laboratories and possible gaps in their functioning is inadequate.

This study sought to assess the capacity and associated issues of public secondary facility-based laboratories in conducting diagnostic test for selected epidemic-prone diseases in Oyo State, Nigeria. The selected diagnostic tests were responsibilities of tier-2 laboratories, and the diseases were bacterial meningitis (caused by *N. meningitidis*), cholera, and measles.

2. Methods

2.1. Study area

This study took place between February and May 2014 in Oyo State located in the Southwest zone of Nigeria. The state comprises 33 Local Government Areas, with 33 public secondary health facilities, of which 29 have functioning secondary facility-based laboratories

2.2. Study design

The study used a facility-based cross-sectional design, which comprises a quantitative survey of laboratories. The head of each secondary facility-based laboratory was interviewed.

2.3. Study facility and size

Seventeen out of 29 (facilities' sampling frame) secondary facility-based laboratories consented to participate in the survey. This yielded a response rate of approximate 60%. Because of the finite nature of the study facilities, sample size was not considered.

2.4. Data collection

This study adapted the WHO laboratory assessment tool (WHO, 2012). This standardized tool rapidly assesses the functional laboratory capacity for diagnosis of diseases of public health importance. The tool was modified (in areas such as sociodemographics of participants, selected diseases, and types of tests required for secondary facility-based laboratories) appropriately to suit the objectives of this study, and the instrument was self-administered. The tool collected information on sociodemographics of the participants, diagnostic testing performance for the selected epidemic-prone diseases, and involvement of the laboratories in public health functions such as disease surveillance. Capacity to carry out a specific diagnostic test was measured based on staff's competence to perform the diagnostic test, availability of up-to-date standard operating procedure, availability and functionality of equipment required for the diagnostic test, availability and potency of reagent, and performance of internal and external quality control.

2.5. Data analysis

Epi-Info 3.5.1 and SPSS 18 were used for data entry and analysis, respectively. Laboratory capacity was assessed on a 100-point scale in which scores were rated low (≤49%), fair (50–79%), and good (≥80%). Descriptive statistics (mean, median, mode, variance, and standard deviation) were used to summarize the data and χ^2 to test association between explanatory and outcome categorical variables (training received by laboratorians and diagnostic testing capacity for the selected diseases). In addition, the independent *t* test was used to check differences in mean for independent group (educational group) and diagnostic testing scores for the selected diseases at $P \leq 0.05$.

2.6. Ethical considerations

Ethics approval was obtained from the Ethics Committee of the Oyo State Ministry of Health, and a written signed informed consent was obtained from each head of laboratory who agreed to participate in this study. Hard copies of completed questionnaires and documents with coded names of the interviewees/hospital/laboratory were locked in a cabinet. Analyzed data were kept confidential in a restricted folder on a personal computer. Only designated team member had access to them. This ensured protection of the participants' identity. Each participant received a ball pen as a form of appreciation.

3. Results

3.1. Characteristics of respondents

Of the 17 heads of laboratory who participated in the study, 10 (58.8%) were males, while 7 (41.2%) were females. The mean age of participants was 42.0 ± 5.1 years with a range of 34–51 years. All the participants belonged to the Yoruba ethnic group. Married respondents represented the majority of participants (16/17, 94.1%), while 1 participant (5.9%) was a widow. Most participants (12/17, 70.6%) were Christian, while 5 (29.4%) were Muslims (Table 1). Nine of the 17 (53%) respondents were educated up to postgraduate level, while 8 (47.1%) stopped education at first-degree level or its equivalent (Medical Laboratory Science degree). Thirteen out of 17 respondents (76.5%) had additional professional certification, while 4/17 (23.5%) participants had none. Two in every 3 (66%) respondents had received training on diagnostic tests for the selected epidemic-prone diseases. The mean duration of service of respondents in their respective facility was 11.9 ± 8.8 years.

3.2. Laboratory diagnostic tests performed for each disease

For meningitis, 1 (5.9%) of the laboratories could carry out bacterial culture, identification, and antimicrobial susceptibility using cerebrospinal fluid (CSF) and blood samples. None of the laboratories could

Table 1
Sociodemographic characteristics of the respondents ($N = 17$).

Variables	*n*	%
Age		
30–39	6	35.3
40–59	11	64.7
Sex		
Male	10	58.8
Female	7	41.2
Ethnicity		
Yoruba	17	100
Marital status		
Married	16	94.1
Widowed	1	5.9
Religion		
Christianity	12	70.6
Islamic	5	29.4
Highest education level		
Tertiary(1st degree/Medical Lab Science)	8	47.1
Postgraduates	9	52.9
Training on diagnostic test for selected diseases		
Yes	11	64.7
No	6	35.3

Lab = Laboratory.

perform latex agglutination diagnostic test on CSF sample. However, 3 (17.6%) of the laboratories could carry out cell count and Gram stain diagnostic test on CSF sample. As regards to cholera, only 1 (5.9%) laboratory could culture fecal sample using alkaline peptone, and none could culture using thiosulfate citrate bile salt (TCBS) sucrose agar. For measles, only 1 (5.9%) of the laboratories could perform IgM (EIA) using serum sample (Table 2).

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3.3. Laboratory diagnostic testing capacity for the selected diseases

Diagnostic testing capacity for bacterial meningitis, cholera, and measles was "low" in all the 17 secondary facility-based laboratories.

3.4. Reasons for low diagnostic testing capacity in the laboratories

Majority of the secondary facility-based laboratories attributed their inability to carry out diagnostic tests for bacterial meningitis, cholera, and measles to nonavailability of equipment (16; 94.1%), no diagnostic kit and associated reagents (16; 94.1%), and diagnostic test not requested by clinicians (13; 76.5%). Other impediments to diagnostic services in the secondary facility-based laboratories included no laboratory guideline (3; 17.6%), staff not trained (3; 17.6%), no technical expertise (2; 11.8%), and cost consideration (2; 11.8%) (Table 3).

3.5. Involvement of the laboratories in public health programs (disease surveillance)

As regards involvement of the laboratories in surveillance activities, 16 (94.1%) of the laboratory representatives knew designated referral laboratories and were aware the laboratory has responsibility in preparedness and public health emergencies. Fifteen (88.2%) were part of surveillance network for epidemic-prone diseases. During outbreaks, 8 (47.1%) laboratories received specimens or diagnostic test requests from public health authorities during field investigation and response to emergencies. Twelve laboratories (70.6%) had referred isolates to designated referral laboratories, and 13 (76.5%) kept registers of persons with notifiable diseases. Furthermore, 12 (70.5%) laboratories sent data to public health (PH) authorities on periodic basis, 7 (41.2%) had duplicates of such data, and 3 (17.6%) had hard copy of list of notifiable diseases. Only 1 of the laboratories provided information to epidemiologists on antimicrobial susceptibility pattern. Likewise, 1 laboratory had guidelines for laboratory investigation of public health events. Only 3 (17.6%) laboratories had emergency sampling kits available.

Table 2
Frequency distribution of laboratories based on diagnostic test they could perform on clinical specimens for selected diseases ($N = 17$).

Disease	Specimen type	Diagnostic test performed	*n*	%
Meningitis	CSF	Cell count	3	17.6
		Latex agglutination	0	0
		Gram stain	3	17.6
		Culture	1	5.9
		Identification tests	1	5.9
		A-M susceptibility	1	5.9
	Blood	Culture and A-M susceptibility	1	5.9
Cholera	Feces	Culture-TCBS	0	0
		Culture Alkaline Peptone	1	5.9
Measles	Serum	IgM by EIA	1	5.9

CSF = cerebrospinal fluid; A-M = antimicrobial; TCBS = thiosulfate citrate bile salt sucrose; IgM = immunoglobulin M; EIA = enzyme immunoassay.

Table 3
Frequency distribution of why the laboratories cannot perform diagnostic tests for the selected diseases ($N = 17$).

Reasons for low testing[a]	*n*	%
No equipment	16	94.1
No technical expertise	2	11.8
Staff not trained	3	17.6
No reagent	16	94.1
No laboratory guideline	3	17.6
Diagnostic test not requested	13	76.5
Cost consideration	2	11.8

[a] Multiple responses.

3.6. Association between specific training on selected epidemic-prone diseases and capacity to carry out diagnostic test for the diseases

There was no association between the "training received by laboratory scientists on diagnostic tests for the selected diseases (categorical)" and the "diagnostic testing capacity for the selected diseases (continuous - raw average point score before categorizing)" (P value $= 0.242$, t value $= -1.219$). Owing to the finite study facilities surveyed, all other statistical analyses using χ^2 were invalid.

4. Discussion

The overall capacity of secondary facility-based laboratories in conducting diagnostic tests for the 3 selected epidemic-prone diseases was low in all 17 (100%) secondary facility-based laboratories who participated in this study.

The low laboratory capacity to carry out diagnostic tests for meningitis was due to lack of equipment, reagents, and clinicians' failure to request for diagnostic test. This low or poor capacity to conduct diagnostic test for meningitis could be due to low prevalence of meningitis in the study area; hence, it was not a priority in planning for laboratory supplies.

In recent times, there were reported outbreaks of diarrheal diseases such as cholera in Oyo State (Adagbada et al. 2012; Oloruntoba et al. 2014; Oluwafemi and Oluwole, 2012 and Ujah et al. 2015). These outbreaks have had no positive influence on capacity of the laboratories to carry out culture of stool specimen, which is the gold standard for laboratory diagnostic confirmation of cholera (CDC, 2018). In addition to reasons such as no diagnostic kit/associated reagent and equipment, the poor capacity possibly is attributed to clinicians not requesting for the diagnostic test. Perhaps, cholera can easily be diagnosed using clinical signs and symptoms such as "vomiting and diarrhea" and "rice water stool" (Sauvageot et al. 2016). However, WHO specifies that a case of cholera must be laboratory confirmed or epidemiologically linked to a confirmed case (WHO, 2017).

Most laboratories could not perform serological diagnostic test for measles. Apart from the nonavailability of reagents and lack of equipment, the low capacity in the laboratories was probably due to physicians' failure to request for the diagnostic test maybe because measles can simply be diagnosed using clinical signs and symptoms (Christian, 2017). Low prevalence of measles (Fatiregun et al., 2014) in the state can also contribute to poor attention to laboratory diagnosis and thus this low capacity.

In this study, 76.5% of the laboratories reported that the clinicians did not usually request diagnostic tests for the selected diseases. This however did not mean that there were no cases of the selected diseases reported at the study facilities (secondary health centers). Rather, it revealed a poor synergy between laboratorians and clinicians. This observed high proportion in "diagnostic tests not requested" conceivably means that clinicians perceived the laboratories were in poor state and so could not carry out quality and reliable diagnostic tests. Consequently, the clinicians may have resorted to the use of clinical symptoms to diagnose the selected diseases instead of requesting for diagnostic tests. For example, with malaria endemic in Nigeria (Jegede et al. 2016), clinicians may use patient symptoms to prescribe malaria drugs instead of requesting for a malaria parasite diagnostic test. However, the use of clinical signs and symptoms is effective in diagnosis of diseases in areas with high prevalence (WHO, 2009). The mean point score for public health functions was average, which indicates that the contribution of the laboratories to disease identification and prevention programs is "fair." Although this is fair, there are still significant shortcomings of diagnostic testing of the selected diseases, which can lead to increase in communicable disease mortality. Hence, laboratorians must understand that they are critical component of the national notifiable disease and public health surveillance system.

4.1. Limitations of the study

Some secondary facility-based laboratories declined participation in the study and hence were not captured in the assessment. A few secondary facility-based laboratories had no functioning laboratory; consequently, there was no assessment for such facilities. The results of the findings are perhaps not generalizable to the whole country but have highlighted deficiencies in laboratory services which the responsible tier (state) of government needs to address.

4.2. Conclusions

This study has provided a snapshot of diagnostic testing capacity in the state secondary health facilities and found that laboratory capacity to carry out diagnostic tests for the selected epidemic-prone diseases was low in the study facilities. In addition, most of the laboratories attributed their low capacity to carry out the diagnostic tests to no equipment, no reagents, and diagnostic test not requested by clinicians.

4.3. Recommendations

Although a more comprehensive evaluation of the diagnostic test system is further required to identify other gaps, equipping the laboratories with specific modern instruments, provision of diagnostic kits and associated test reagents and consumables, improving laboratory infrastructure, and recruitments of more laboratory scientists are recommended. These are the responsibilities of the State Government as well as maintenance. It will enable the laboratories to boost its capacity in prompt detection and case confirmation and improve on service delivery in the hospitals.

Creating awareness of the importance of diagnostic tests and encouraging clinicians to embrace the use of diagnostic tests by participating in all phases of quality assurance program are also recommended. This will foster laboratory–clinician relationships and bolster clinical trust in laboratory results. However, this does not restrict clinicians from using case classification to prescribe appropriate therapy during emergency conditions.

Declaration of competing interest

The authors declare that they have no financial or personal relationship(s) that may have inappropriately influenced them in writing this paper.

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