

## DRIVERS OF BIOMEDICAL ENGINEERING SERVICES AMONG TEACHING HOSPITALS IN SOUTHWESTERN NIGERIA

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### Abstract

*This study examined the existing Biomedical Engineering (BME) services in the selected teaching hospitals in Southwestern Nigeria and it also investigated factors influencing the effective and efficient BME service delivery in the selected hospitals. These were with a view to improving total healthcare delivery service of the selected hospitals. A total of two hundred and ten (210) copies of structured questionnaire were distributed among three (3) teaching hospitals selected for the study. Thirty (30) copies of questionnaire were administered to nurses, twenty (20) to medical doctors and ten (10) to each of medical laboratory scientists and other health professionals totaling seventy (70) in each of the hospitals. The questionnaire elicited information on existing BME services rendered in each of the selected hospital and it also collected data on the factors influencing the effective BME service delivery. The study was carried out in the University College Hospital (UCH), Ibadan, Ladoke Akintola Univeristiy of Technology Teaching Hospital (LTH), Osogbo and Ekiti state University Teaching Hospital, Ado-Ekiti. The data collected were coded and analysed for both descriptive and inferential statistics. The results showed that majority of the respondents were aware of the existing BME services in their respective hospitals. Some of these services among others were consulting services (56.3%), medical equipment management services (58.07%), medical gas management services (58.37%) and administrative services (71.3%). It was also found that some of the factors that influence the effective and efficient BME service delivery includes; funding ( $F = 2.778, p < 0.05$ ), personnel management ( $F=2.157, p < 0.05$ ), maintenance work schedule ( $F = 0.934, p < 0.05$ ), availability of relevant documentation ( $F = 4.119, p < 0.05$ ) among others. The study concluded that healthcare delivery can be improved in the selected hospitals by the provision of adequate funding, training and education of BME staff, provision relevant documentations and periodic users' training.*

Keywords: Biomedical Engineering, Teaching Hospital, healthcare delivery, Health professionals, medical equipment management, documentations.

### Introduction

Biomedical engineering (BME) has been described as the application of engineering principles and design concepts to medicine

and biology for healthcare purposes (Enderle and Bronzino, 2012). BME is also described as discipline that advances knowledge in engineering, biology and

medicine, and improves human health through cross-disciplinary activities that integrates engineering sciences with the biomedical sciences and clinical practice. This field seeks to close the gap between engineering and medicine: It combines the design and problem solving skills of engineering with medical and biological sciences to advance healthcare treatment, including diagnosis, monitoring and therapy (Khan *et al.*, 2013). BME has only recently emerged as its own discipline, compared to many other engineering fields. During the last two decades its growth has paralleled that of the electronic and computer industries. Its contributions to improved medical treatment have resulted in a better quality of life and greater life expectancy in both the developed and the developing countries (Okorie, 2015).

However, the introduction of BME has influenced the healthcare system in both advanced countries and developing nations of Africa. For instance, in advanced countries, the quality of healthcare improves with availability of medical device for patient use and thus increases the employment rate of medical engineers, in Asian countries, the number of medical technicians increase with complexity of the medical facilities and the quality of the healthcare services (Elfani and Putra, 2013) and the introduction of medical equipment and engineering training in hospitals has caused considerable improvement in medical equipment performance in Ghana (Zienna, 2008). In Nigeria, the bulk of

biomedical engineering practices occur in the health institutions represented by the hospitals and the health ministries. Only a hand full of BME practice occurs in the industries because there are few biomedical engineering manufacturing industries (Nkuma-Uda and Mazi, 2009). Abraham (2014) also reported that BME has contributed to effective healthcare delivery through the services provided by this profession in Nigerian hospitals.

Teaching hospitals provide tertiary care which requires sophisticated technology, multiple specialists and sub specialists, diagnostic support group and intensive care facilities and render specialized services with sophisticated healthcare equipment and machinery that can only be maintained by experts. They function round the clock and require effective support of critical infrastructure such as power supply for operating theaters, medical gas in intensive care units and sophisticated equipment for diagnosis and treatment (Oladejo *et al.*, 2015). Teaching hospitals are distributed across the country and they handle complex health cases either as referrals from general hospitals or on direct admission to its own. They have such features as accident and emergency unit, diagnostic units, ward units, treatment units and outpatient consultation units. All these units are to be equipped with the necessary facilities and staffed with skilled personnel. They also conduct researches and provide outcome to the government in a way of influencing health policies and they are supposed to be

fully developed and accredited for teaching of various medical disciplines (Ademiluyi and Aluko-Arowolo, 2009). Oladejo *et al* (2015) observed that the maintenance units (Biomedical Engineering inclusive) of teaching hospitals lack competent maintenance staff considering the nature of the facilities they are to maintain and this was linked to failures and delays in rectifying breakdown of crucial medical equipment. It was also reported that the maintenance units of tertiary hospitals are poorly staffed and only very few qualified staff are recruited and most are technicians. It was also observed that insufficient provision of funds and tools accounted for their poor performance and that the staffs in the maintenance unit do not undergo staff training and development even in the face of highly sophisticated medical equipment and technology (Oladejo *et al.*, 2015). The specific objectives of the study are to investigate the awareness of existing BME services among healthcare professionals within the selected teaching hospitals in Southwestern Nigeria and to identify factors influencing effective delivery of the services in the selected hospitals.

## Materials and Methods

### Study Area

Nigeria is divided into six geopolitical zones namely; Northwestern, Northcentral, Northeastern, Southwestern, Southsouthern and Southeastern. Out of these, Southwestern Nigeria was selected for the purpose of the study. Southwestern Nigeria comprises six states: Lagos, Ogun,

Oyo, Osun, Ekiti and Ondo states. Three states were selected out of the six states in southwestern Nigeria and they are; Oyo, Osun and Ekiti states. Teaching hospitals are located across each of these states, in Oyo state, there are two teaching hospitals namely University College Hospital (UCH), Ibadan and Ladoke Akintola University of Technology (LAUTECH), Ogbomoso. Also in Osun state, Obafemi Awolowo University Teaching Hospitals Complex (OAUTHC), Ile-Ife and Ladoke Akintola University of Technology Teaching Hospital (LTH), Osogbo. And in Ekiti state, Federal Teaching Hospital, Ido-Ekiti and Ekiti State University Teaching Hospital (EKSUTH), Ado-Ekiti. University College Hospital (UCH), Ibadan was selected from Oyo state, Ladoke Akintola University of Technology Teaching Hospital (LTH), Osogbo was selected from Osun state, Ekiti State University Teaching Hospitals (EKSUTH), Ado Ekiti was selected from Ekiti state while the pilot study was carried out at Obafemi Awolowo University Teaching Hospitals Complex (OAUTHC), Ile Ife, Osun state.

### Research Instruments

Primary and secondary data collection methods were used for the study. Mixed methods of quantitative and qualitative data collection were used to obtain the primary data. The quantitative data were collected through questionnaire while the qualitative data were collected through personal interviews and observation methods. The secondary data were collected through textbooks, journals articles, workshops, seminars and

other relevant published materials on biomedical engineering services and technology management.

#### Study Population and Sampling Techniques

For the purpose of the study, one teaching hospital is selected from each of the selected southwestern states. Purposive sampling was used to select the hospitals so that the state owned and federal owned teaching hospitals were included across the zone. The study population were medical doctors, nurses, medical laboratory scientists and others healthcare professionals who engage the use of medical equipment in carrying out their duties. The questionnaire was administered among medical doctors (20), nurses (30), medical laboratory scientists (10) and other healthcare professionals (10), totaling seventy (70) in each of the selected hospitals and a total of two hundred and ten (210) copies of questionnaire in the three teaching hospitals. Also semi structured interviews were conducted with some of the respondents in each of the selected teaching hospitals so as to explore their views on the BME services rendered and the impacts of the services on patient care in the hospitals.

#### Variables and their Measurement

The variables employed in the study were itemized based on the objectives such as socio-demographic data, the knowledge of the respondents about biomedical engineering services and the factors influencing the effective biomedical

engineering service. The socio-demographic variables of the respondents include;

- (i) Gender; this was measure on a 2-item code where, 1 represents Male and 2 represents Female
- (ii) Education which was measured by highest academic qualification of the respondents. This is an ordinal variable of 1 to 5 representing SSCE, OND/NCE, HND, Bachelor's and Master/Doctorate degrees.
- (iii) Years in service was measured on 4-point code where 1 represents 1-5 , 2 represents 5-10, 3 represents 11-20 and 4 represents 21 and above

Biomedical engineering services were divided into four categories which are; consultancy services, medical equipment management services, medical gas management services and administrative services. The knowledge of the respondents about biomedical engineering services were measured using a 3-point scale, where Yes = 2, No = 1 and I don't know = 0.

- (i) The consultancy services were captured by three proxy variables which are: the need assessment or pre-purchase evaluation, medical device recommendation and provision for end user training.
- (ii) The medical equipment management services were captured by three proxy variables such as: performance of incoming inspection of new equipment, installation of new medical equipment, preventive and corrective (repairs) maintenance.

- (iii) The medical gas management services were captured by three proxy variables which are medical gas production and distribution of medical gas, installation and maintenance of gas pipelines and medical gas records.
- (iv) The administrative services were captured by: involvement of biomedical engineering section of the hospital by its representation in management constituted committee within the hospital. Six major committees were used as variable to measure this category.

The factors influencing the effective BME service delivery were captured by six variables which were measured on a 6-point Likert type scale, where Very high = 5, High = 4, Moderate = 3, Low = 2, Very low = 1 and No effect = 0.

The variables that were measured include funding, personnel/manpower management, reporting procedures, maintenance cost, maintenance work schedule and availability of relevant documentations.

#### Data Analysis

The data were analyzed using both descriptive and inferential statistics. Frequency; percentages and mean rank were employed for descriptive analysis while ANOVA and linear regression were used for inferential analysis. The results of the analysis were presented in form of tables.

#### Results

##### Questionnaires Administration

Table 1 shows the result of information about the respondents in terms of number of questionnaire administered and retrieved. Seventy (70) copies of questionnaire were administered in each of the three selected teaching hospitals (EKSUTH, UCH, and LTH) making 210 respondents in total. Out of the administered questionnaire, 64/(91.42%) were retrieved from EKSUTH, 61/(87.14%) were retrieved from UCH and 64/(91.42%) were also retrieved from LTH, respectively making 189/(90%) copies of questionnaire retrieved in total. Therefore, analysis and interpretation of data for the study was based on 189/(90%) of questionnaire retrieved from the field.

##### Social demographic characteristics of the respondents

Table 2 shows the result of socio demographic information of the respondents in terms of gender, education and years in service. The Table reveals that 42.3% are male and 54% are female. This implies that there are more females in patient care job than males and also suggested that there are more female staffs in the hospitals than their male colleagues. The Table further reveals that about 58.7% of the respondents have Bachelor's degree as their highest educational qualification, 27.5 and 4.2% of the respondents have Master/Doctorate degree and HND, respectively while minority (0.5 and 0.5%) of the respondents have OND/NCE and SSCE certificate respectively.

This implies that most of the respondents who engage in the use of medical equipment had requisite academic requirements which might help them to understand easily and manage the technology. The Table also shows that 33.3, 29.1 and 22.8% of the respondents have spent 1-5, 6-10 and 11-20 years in service, respectively while only 7.4% of the respondents have spent 21 years and above. This implies that most medical equipment users had about 1-20 years of experience in service. They are either in the early stage or middle stage of their career development; therefore they will be

committed to work assigned to them. Although there are indications that staffs that are at the peak of their career may be involved in the use of medical equipment, maybe where experience is required to do so but they are rarely involved in the use of medical equipment.

Tables 3, 4, 5 and 6 show the results of data analysis of the knowledge of the respondents about BME services in the selected hospitals and the investigated factors influencing effective BME service delivery in the hospitals

Table1: Distribution of questionnaire administered and retrieved

Hospital Name	Number of Questionnaire	Number of Questionnaire	Rate of Retrieval (%)
	Administered	Retrieved	
EKSUTH	70	64	91.42
UCH	70	61	87.14
LTH	70	64	91.42
Total	210	189	90.00

*Source: Author's survey*

Legend

EKSUTH = Ekiti State University Teaching Hospital, Ado Ekiti. Ekiti state.

UCH = University College Hospital, Ibadan. Oyo state.

LTH = Ladoko Akintola University of Technology Teaching Hospital, Osogbo. Osun state

Table2: Socio-demographic data

Characteristics of the respondents	Frequency	Percentage (%)
<b>Gender</b>		
Male	80	42.3
Female	102	54.0
No response	7	3.7
Total	189	100
<b>Education</b>		
SSCE	1	0.5
Ordinary National Diploma (OND)/National Certificate Examination (NCE)	1	0.5
Higher National Diploma (HND)	8	4.2
Bachelor's degree	111	58.7
Master/Doctorate degree	52	27.5
No response	16	8.5
Total	189	100
<b>Years in Service</b>		
1-5 years	63	33.3
6-10 years	55	29.1
11- 20 years	43	22.8
21 and above	14	7.4
No response	14	7.4
Total	189	100

*Source: Author's survey*

Table 3: BME services in selected hospitals

BME services		Hospitals			
		EKSUTH (%)	UCH (%)	LTH (%)	Total (%)
<b>BME Consultancy Services</b>					
BME involved Pre-purchase evaluation (need assessment)	No	4.2	5.8	5.3	15.3
	Yes	19.6	16.4	15.9	51.9
	I don't know	10.1	10.1	12.7	32.8
Total		33.9	32.3	33.9	100.0
BME involved Medical Equipment recommendation	No	3.3	3.8	3.3	10.3
	Yes	23.4	22.8	19.0	65.2
	I don't know	8.2	3.8	12.5	24.5
Total		34.8	30.4	34.8	100.0
User training on newly installed medical equipment by BME	No	7.1	3.3	9.3	19.7
	Yes	17.5	24.0	10.4	51.9
	I don't know	9.8	3.3	15.3	28.4
Total		34.4	30.6	35.0	100.0
Weighted Average on BME consultancy services	No	4.87	4.3	5.97	15.1
	Yes	20.17	21.07	15.1	56.3
	I don't know	9.37	5.73	13.5	28.6
Total		34.4	31.1	34.57	100
<b>BME Medical Equipment Management Services</b>					
BME perform in-coming inspections on the newly purchased equipment	No	4.9	7.1	9.3	21.4
	Yes	21.4	23.1	15.9	60.4
	I don't know	8.8	-	9.3	18.1
Total		35.2	30.2	34.6	100.0
BME do the installations of medical equipment	No	5.6	10.1	8.9	24.6
	Yes	23.5	18.4	17.9	59.8
	I don't know	6.7	-	8.9	15.6
Total		35.8	28.5	35.8	100.0
BME perform regular preventive maintenance and repairs on medical equipment	No	7.2	11.6	14.4	33.1
	Yes	22.1	18.8	11.6	52.5
	I don't know	5.5	-	8.8	14.4
Total		34.8	30.4	34.8	100.0
Weighted Average on medical equipment management services	No	5.9	9.6	10.87	26.37
	Yes	22.0	20.1	16.07	58.07
	I don't know	7.0	-	9	16.0
Total		34.9	29.7	35.93	100

Source: Author's survey

Legend

EKSUTH = Ekiti State University Teaching Hospital, Ado Ekiti. Ekiti state.

UCH = University College Hospital, Ibadan. Oyo state.

LTH = Ladoke Akintola University of Technology Teaching Hospital, Osogbo. Osun state.



Table 4: BME services in selected hospitals continued

BME services		Hospitals			
		EKSUTH	UCH	LTH	Total
		(%)	(%)	(%)	(%)
Medical gas Management Services					
BME involved or medical gas production	No	12.7	16.2	9.2	38.0
	Yes	23.9	19.0	17.6	60.6
	I don't know	1.4	-	-	1.4
Total		38.0	35.2	26.8	100.0
BME is involved in gas pipelines installation and maintenance	No	12.4	19.7	8.8	40.9
	Yes	24.1	16.1	16.1	56.2
	I don't know	2.9	-	-	2.9
Total		39.4	35.8	24.8	100.0
BME keep medical gas records	No	14.6	16.0	9.0	39.6
	Yes	20.8	19.4	18.1	58.3
	I don't know	2.1	-	-	2.1
Total		37.5	35.4	27.1	100.0
Weighted Average on Medical gas management services	No	18.23	17.3	9.0	39.5
	Yes	22.94	18.17	17.27	58.37
	I don't know	2.13	-	-	2.13
Total		38.3	35.47	26.27	100
BME Administrative services	No	8.3	9.6	9.2	27.1
	Yes	27.7	27.0	16.6	71.3
	I don't know	1.6	-	-	1.6
Total		37.6	36.6	25.8	100.0

Source: Author's survey

Legend

EKSUTH = Ekiti State University Teaching Hospital, Ado Ekiti. Ekiti state.

UCH = University College Hospital, Ibadan. Oyo state.

LTH = Ladoko Akintola University of Technology Teaching Hospital, Osogbo. Osun state.

Table 5: Factors influencing effective BME service delivery in selected hospitals

Criteria	Factors	Mean	Weighted Average
Funding	Government budget on equipment procurement and maintenance	3.74	3.83
	Hospital board decisions on financial issues	3.88	
	Hospital management policy on procurement procedures	3.89	
	Provision of funds for emergency spending	3.80	
Personnel/Manpower management	Staff adequacy	3.72	3.65
	Number of biomedical engineering staff on duty	3.66	
	Number of duty shift per day	3.62	
	Supervision of staff	3.61	
Reporting Procedures	Process of work order request	3.70	3.65
	Response to work order request	3.70	
	Approximate equipment downtime before the equipment repairs	3.60	
	Time to another work order request on the equipment	3.61	
Maintenance cost	Availability of spare parts	3.66	3.75
	Availability of fund	3.73	
	Attitude of maintenance personnel	3.66	
	Age of the equipment	3.73	
Maintenance work schedule	Equipment periodic servicing and calibrations	3.70	3.71
	Periodic performance testing and equipment evaluation	3.73	
	Periodic safety testing	3.69	
	Periodic overhauling	3.71	
Documentation	Availability of maintenance documentation	3.69	

Source: Author's survey

Legend

BME = Biomedical Engineering

Scale: Very High = 5, High = 4, Moderate = 3, Low = 2, Very Low = 1 and No Effect = 0

Table 6: Factors influencing BME service delivery in selected hospitals

Factors	EKSUTH	UCH	LTH	F	p-VALUE
Funding	4.00 <sup>a</sup>	3.85 <sup>a</sup>	4.22 <sup>a</sup>	2.778	0.042
Personnel/ Manpower Management	3.76 <sup>a</sup>	3.88 <sup>a</sup>	3.84 <sup>a</sup>	2.157	0.027
Reporting procedures	3.57 <sup>a</sup>	3.90 <sup>a</sup>	3.80 <sup>a</sup>	0.807	0.653
Maintenance cost	3.78 <sup>a</sup>	3.88 <sup>a</sup>	3.98 <sup>a</sup>	3.428	0.036
Maintenance work schedule	3.60 <sup>b</sup>	3.90 <sup>a</sup>	3.79 <sup>a</sup>	0.934	0.095
Documentation	4.21 <sup>a</sup>	4.66 <sup>b</sup>	4.40 <sup>a</sup>	4.119	0.018

Source: Author's survey

<5%

a = significant, b = not significant

Very High = 5, High = 4, Moderate = 3, Low = 2, Very Low = 1, No Effect = 0

#### Legend

EKSUTH = Ekiti State University Teaching Hospital, Ado Ekiti. Ekiti state.

UCH = University College Hospital, Ibadan. Oyo state.

LTH = Ladoke Akintola University of Technology Teaching Hospital, Osogbo. Osun state.

#### Discussion

##### Knowledge of the Respondents about Biomedical Engineering Services

Table 3 and Table 4 show the cross tabulation of the respondents' hospital and their knowledge about BME services in the hospital. Table 3 reveals that 4.2, 5.8 and 5.3% from EKSUTH, UCH and LTH, respectively making 15.3% of the respondents did not agree that BME is involved in pre-purchase evaluation (need assessment) in their hospital, 19.6, 16.4, and 15.9% from EKSUTH, UCH and LTH, respectively making 51.9% of the respondents agreed that BME is involved in

pre-purchase evaluation (need assessment) in their hospital while 10.1, 10.1 and 12.7% from EKSUTH, UCH and LTH, respectively making 32.8% of the respondents did not know if BME is involved in pre-purchase evaluation. The table also shows that 3.3, 3.8 and 3.3% from EKSUTH, UCH and LTH respectively making 10.3% of the respondents did not agree that BME is involved in medical equipment recommendation in their hospital, 23.4, 22.8 and 19% from EKSUTH, UCH and LTH, respectively making 65.2% of the respondents agreed that BME is involved in medical equipment recommendation in their hospital while 8.2, 3.8 and 12.5%

in medical equipment recommendation in their hospital while 8.2, 3.8 and 12.5% from EKSUTH, UCH and LTH, respectively making 24.5% of the respondents did not know if BME is involved medical equipment recommendation. The table further reveals that 7.1, 3.3 and 9.3% from EKSUTH, UCH and LTH, respectively making 19.7% of the respondents did not agree that BME provides user training on newly installed equipment in their hospital, 17.5, 24 and 10.4% from EKSUTH, UCH and LTH, respectively making 51.9% of the respondents agreed that BME provides user training on newly installed equipment while 9.8, 3.3 and 15.3% from EKSUTH, UCH and LTH, respectively making 28.4% of the respondents did not know if BME provides user training on newly installed equipment. Table 3 also shows that 4.9, 7.1 and 9.3% from EKSUTH, UCH and LTH, respectively making 21.4% of the respondents did not agree that BME performs incoming inspections on the newly purchased medical equipment in their hospital. About 21.4, 23.1 and 15.9% from EKSUTH, UCH and LTH, respectively making 60.4% of the respondents agreed that BME perform incoming inspections on the newly purchased medical equipment in their hospital while 8.8 and 9.3% from EKSUTH and LTH, respectively making 18.1% of the respondents did not know if BME perform incoming inspections on the newly purchased medical equipment in their hospital. Table 3 further reveals that 5.6, 10.1 and 8.9% from EKSUTH, UCH and LTH, respectively making 24.6% of the respondents did not agree that BME do the

installations of medical equipment in their hospital, 23.5, 18.4 and 17.9% from EKSUTH, UCH and LTH, respectively making 59.8% of the respondents agreed that BME do the installations of medical equipment in their hospital while 6.7 and 8.9% from EKSUTH and LTH, respectively making 15.6% of the respondents did not know if BME carried out the installations of medical equipment. The Table also shows that 7.2, 11.6 and 14.4% from EKSUTH, UCH and LTH, respectively making 33.1% of the respondents did not agree that BME perform regular preventive maintenance and repairs on medical equipment in their hospital. About 22.1, 18.8 and 11.6% from EKSUTH, UCH and LTH, respectively making 52.5% of the respondents agreed that BME perform regular preventive maintenance and repairs on medical equipment in their hospital while 5.5 and 8.8% from EKSUTH and LTH, respectively making 14.4% of the respondents did not know if BME perform regular preventive maintenance and repairs on medical equipment.

Table 4 shows that 12.7, 16.2 and 9.2% from EKSUTH, UCH and LTH, respectively making 38.0% of the respondents did not agree that BME is involved in medical gas production and distribution in their hospital. About 23.9, 19.0 and 17.6% from EKSUTH, UCH and LTH, respectively making 60.6% of the respondents agreed that BME is involved in medical gas production and distribution in their hospital while 1.4% from EKSUTH of the respondents did not know if BME section is involved in medical gas production and distribution. Table 4 also shows that 12.4, 19.7 and 8.8% from

EKSUTH, UCH and LTH, respectively making 40.9% of the respondents did not agree that BME is involved in gas pipeline installation and maintenance in their hospital.

About 24.1, 16.1 and 16.1% from EKSUTH, UCH and LTH, respectively making 56.2% of the respondents agreed that BME section is involved in gas pipeline installation and maintenance in their hospital while 2.9% from EKSUTH of the respondents did not know if BME section is involved in gas pipeline installation and maintenance. The Table further reveals that 14.6, 16.0 and 9.0% from EKSUTH, UCH and LTH, respectively making 39.6% of the respondents disagreed that BME section keeps medical gas records in their hospital. About 20.8, 19.4 and 18.1% EKSUTH, UCH and LTH, respectively making 58% of the respondents agreed that BME section keeps medical gas records in their hospital while 2.1% from EKSUTH of the respondents don't know if BME section keeps medical gas records. Table 6 further shows that about 8.3, 9.6 and 9.2% from EKSUTH, UCH and LTH, respectively making 27.6% of the respondents did not agree that BME is involved in hospital administrative services in their hospital. About 27.7, 27 and 16.6% from EKSUTH, UCH and LTH, respectively making 71.3% of the respondents agreed that BME is involved in hospital administrative services in their hospital.

The results of the analysis of variables shown in Tables 3 and 4 reveal that BME medical equipment management services were known to the respondents from the

hospitals. Most of the respondents were knowledgeable of these services while those who were not aware of the services may be as a result of lack of information about the services or poor interaction with the BME section of the hospital. However, Atles (2008) has mentioned it in his explanation of the roles of BME in hospitals. It is worth to know that the use of medical gas is common only among some doctors and some nurses.

**Factors Influencing the Effective Biomedical Engineering Service Delivery**  
Tables 5 and 6 show the factors influencing the effective delivery of biomedical engineering services in the selected teaching hospitals. Table 5 shows the mean rank of factors influencing the effective delivery of biomedical engineering services and the weighted average of the latent variables in the hospital. The factors include: government budget on equipment procurement and maintenance (3.74), hospital board decisions on financial issues (3.88), hospital management policy on procurement procedures (3.89), provision of funds for emergency spending (3.80), staff adequacy (3.72), number of biomedical engineering staff on duty (3.66), number of duty shift per day (3.62), supervision of staff (3.61), process of work order request (3.70), response to work order request (3.70), approximate equipment downtime before the equipment repairs (3.60), time to another work order request on the equipment (3.61). The Table also shows that respondents agreed that these factors influence the effective delivery of

biomedical services in the hospital. The factors are availability of spare parts (3.66), attitude of maintenance personnel (3.72), age of the equipment (3.87), equipment periodic servicing and calibrations (3.70), periodic performance testing and equipment evaluation (3.73), periodic safety testing (3.69), periodic overhauling (3.71), availability of technical documentation (3.77), availability of installation documentation (3.78), availability of maintenance documentation (3.69), availability of troubleshooting and repairs documentation (3.70), and availability of upgrade and update documentation (3.61).

The Table also shows the weighted average of the six latent variables such as; funding (3.83), personnel/manpower management (3.65), reporting procedures (3.65), maintenance cost (3.75), maintenance work schedule (3.71) and availability of relevant documentation (3.71). The indication of these is that the respondents agreed that the factors mentioned were highly influencing BME service delivery in their respective hospital. The most influencing factor is funding (3.83) and this is line with the submission of Atles (2008) that one of the major factors that may influence the performance of any organization is funding and financial management. According to Atles (2008), most medical equipment requires operating cost which is associated with keeping the equipment working the way it was intended, servicing it when it fails and performing actions to keep it usable to its useful life and beyond. From the inferential

analysis, ANOVA shown in Table 6 shows that the six latent variables used to capture the factors were significantly influencing the effective delivery of biomedical engineering service in the selected hospitals.

These are funding ( $F=2.778$ ,  $p<5\%$ ), personnel/manpower management ( $F=2.157$ ,  $p<5\%$ ), medical equipment failure reporting procedures ( $F=0.807$ ,  $p>5\%$ ), maintenance cost ( $F=3.428$ ,  $p<5\%$ ), maintenance work schedule ( $F = 0.934$ ,  $p<10\%$ ), and availability of relevant documentations ( $F=4.119$ ,  $p<5\%$ ).

Respondents from the three hospitals were interviewed so as to establish that the factors influencing the effective delivery of biomedical engineering service in their institutions. The respondents interviewed from EKSUTH reported that funding is the prime factor among others that are affecting effective delivery of biomedical engineering services in the institution. Personnel competence and the equipment failure reporting procedures are also part of the major factors affecting effective delivery of biomedical engineering services in the institution. Also the respondents from UCH reported funding, insufficient BME staff compared to the hospitals size, lack of proper training on the use and maintenance of modern equipment, management of maintenance request order, poor records of medical equipment are the major factors that are influencing the effective BME service delivery and in LTH the respondents reported that the major factor is funding

and insufficient BME staff. These factors particularly funding, staff training and education, staff management and documentation have all been identified in the literature as part of limiting factors to BME service performance. This is in line with reports of some scholars on these factors such scholars include Goffin and Price, 1996; Nkuma–Udah, et al., 2009 and Atles, 2008. It is however interesting to note that in spite of all these factors, majority of the respondents still rate the BME performance in their respective hospitals beyond average. This suggested that BME would likely perform better if these factors are eliminated.

#### Conclusion

BME has been contributing to effective healthcare delivery through the services provided by this profession in Nigerian hospitals (Abraham, 2014). Oladejo *et al.*, (2015) reported that the maintenance units (BME inclusive) of tertiary hospitals lack competent maintenance staff considering the nature of the facilities they are to maintain and this was linked to failures and delays in rectifying breakdown of crucial medical equipment and that the maintenance units of tertiary hospitals are poorly staffed and only very few qualified staff are recruited and most are technicians. It was also observed that insufficient provision of funds and tools accounted for their poor performance and that the staffs in the maintenance units do not undergo staff training and development even in the face of highly sophisticated medical equipment and

technology. The aim of the study was to evaluate BME services and their relevance in improving total healthcare delivery service of the selected hospitals. The study examined the existing BME services and investigated the factors that were influencing the effective service delivery of the selected teaching hospitals. It was discovered from the study that majority of healthcare professionals of the selected hospitals were aware of various BME services in their institutions and these services have been contributing to the overall healthcare service delivery in the hospitals. The study however identified inadequate funding, lack of proper training and education of BME staff and non availability of relevant documentation have significant influence on the effective and efficient BME services delivery.

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