Journal of Medical and Applied Biosciences
ISSN: 2277 - 0054
Volume 5, Number 2, 2013

Trends in Diagnostic Imaging Workload and Utilization in a Teaching Hospital

Arimie C.O.D.
Department of Radiology
University of Port Harcourt Teaching Hospital, Port Harcourt, Rivers State, Nigeria.
E-mail: codarimie@yahoo.com

ABSTRACT

Diagnostic imaging is an invaluable tool of diagnosis in medicine. Despite its value, diagnostic imaging equipments are expensive and difficult to maintain. To that extent, there is increasing concern among health policy planners that the growth in utilization of high-technology procedures, such as diagnostic imaging procedures, is a major factor responsible for the rapid growth in health care costs. Hence, it was the purpose of this study to determine the trends in workload and utilization rates of diagnostic imaging in the University of Port Harcourt Teaching Hospital (UPTH), Port Harcourt, Rivers State, Nigeria between January 2010 and December 2012. Data comprising records of attendance of patients to the hospital clinics, the number of diagnostic imaging procedures, and workload measured in Relative Value Units (RVU) for the respective imaging modalities for the years 2010, 2011 and 2012 were analyzed. The results show that Conventional radiography is the most widely used imaging modality constituting over 50% of the total diagnostic imaging in the three year period. Ultrasound Scanning (USS) is the second most used modality (over 40%) followed by CT (over 2%), MRI (over 1%) and Mammography (less than 1%). In 2010 the overall diagnostic imaging utilization rate was 908.6 (≅ 909) examinations per 10,000 patients. In 2012 the rate was 732.6 (≅ 733), representing a 19.4% decrease over 3 years. It was concluded that some of the imaging modalities were not utilized optimally and did not justify government spending on them particularly, MRI, and Mammography although, it was established that equipment breakdowns contributed significantly to this trend.

Keywords: Diagnostic Imaging, Utilization, Workload and Relative Value Unit.

INTRODUCTION

Diagnostic imaging has to a large extent, revolutionized health care management and is one of the most used diagnostic tools in medicine. Diagnosis of medical conditions using imaging modalities such as; radiography (medical x-ray imaging),

Computed Tomography (CT), Mammography, Magnetic Resonance Imaging (MRI), Ultrasound Scanning (USS), etc. makes treatment and management of patients easier and more reliable. However, there is increasing concern among health policy planners and managers that the growth in utilization of high-technology procedures, including diagnostic imaging procedures, is a major factor responsible for the rapid growth in health care costs.

In recent times, one of the most important health care service issues in Nigeria concerns the level of provision of medical imaging service, changes in government policies and regulations relative to healthcare reimbursement mechanism has led to cost-restrictive measures within the health care system. Budgetary allocation to health in the last 5years stood at an average of 5% of the national budget. In 2012, out of the N283bn allocated to health, only N13.7bn (4.8%) was allocated for health and medical equipments [1]. Public Private Partnership Arrangement (PPPA) is being encouraged in realization that government alone cannot adequately provide for the health care needs of the citizenry. Against this backdrop, it is obvious that profitability through optimal utilization of diagnostic imaging is the guarantee for continuity in the business of providing medical imaging services. Research has shown that Computed Tomography (CT) facility in a teaching hospital can generate enough profit to sustain itself [2].

Despite the high cost, the demand for diagnostic imaging is on the rise. A visit to any radiology facility of public hospitals in Nigeria tells the story. The workload of staff has also increased tremendously thus necessitating diagnostic imaging workload measurement. The use of study numbers (volume) to determine diagnostic imaging workload and throughput had been described as old-fashioned, discredited and inappropriate [3]. This is because the method fails to account for the diversity among the procedures in terms of complexity and resource consumption. Study volume should not be used in an unfiltered and un-weighted manner. Measurement of true workload should include adjustment for procedure complexity [3, 4]. There is no universally-applicable and universally-accepted weighting system presently in use. Most weighting systems that exist at present were developed as tools to aid insurance reimbursement or other matters not directly concerned with staffing [3]. Efforts to assess workload and efficiency in individual departments must take account of local circumstances and clinical demand [3, 5]. Relative value method of workload measurement

for radiology facilities is the only statistically appropriate type of analysis given the diversity that exists among diagnostic imaging procedures [5]. Also, relative value method provides an ordering of actual workload based on resource consumption [6] and thus, provides a more comprehensive view of work changes than evaluations of the same changes by traditional procedure value method [7, 8].

It has been reported in the United States of America (USA) that the utilization of Noninvasive Diagnostic Imaging (NDI) in populations of commercially insured patients younger than 65 years is 758 studies per 1,000 subscribers per year [9], and in populations of patients younger than 65 years enrolled in health maintenance organizations, mean utilization is 666 studies per 1,000. In another study [10], a 3.8% increase in the rate of NDI utilization occurred during the 6-years study period between 1993 and 1999.

There is no evidence of published data available in Nigeria on this subject matter in the literature. Hence, it was the purpose of this study to determine the trends in workload and utilization rates of diagnostic imaging in the University of Port Harcourt Teaching Hospital (UPTH), Port Harcourt, Rivers State, Nigeria.

Knowledge of trends in workload and utilization rate of diagnostic imaging facilities is of importance in predicting the future health care resources needed for sustainability. Estimating trends in workload enables adequate planning of staff need, equipment need and expansion of present program.

MATERIALS AND METHOD

Historical data comprising records of attendance of patients to the hospital clinics, and the number of diagnostic imaging procedures (study volume) for the respective imaging modalities for the year 2010, 2011 and 2012 were collected from the statistical database of the departments of medical records and radiology, UPTH respectively and used for this study.

In the radiology facility, the imaging modalities available include conventional radiography (routine radiography, contrast radiological studies and fluoroscopy), mammography, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), and Ultrasound Scanning (USS). The procedures done using these imaging modalities were classified into 16 diagnostic categories for ease of analysis. The total procedure volume and the Relative Value Units (RVU)

were determined for each corresponding diagnostic imaging. The RVU scale used was the CPT-4 code published in [5]. The CPT-4 code was used because at the time of conducting this research, the department had no record of relative value units for its diagnostic procedures and there was no evidence of such record elsewhere in the country. The numbers of RVU for each code were calculated by multiplying the component RVU assigned to that code by the number of examinations performed. The results represent a proxy for the relative amount of work for each procedure. The RVU for each of the 16 diagnostic categories was determined by summing the RVU of examinations classified under each category. Because no RVU is assigned to screening mammography in the Medicare Resource Based Relative Value Scale, the assumption that a screening mammogram should carry 80% of the professional component RVU of a diagnostic mammogram, based on recommendation of the American College of Radiology [11], was adopted. The diagnostic imaging utilization rates per 10,000 patients were calculated and the percentage change in utilization rate during the 3-year period between January, 2010 and December, 2012 was calculated for the 16 categories and five modalities by subtracting the 2010 value from the 2012 value and dividing the difference by the 2010 value. Traditionally, the workload of health care facilities is segmented into outpatient and inpatient categories. However, this study captured only patients on their first visit to the hospital and so, did not consider inpatient days in the analysis. The records show that there were 226,881 patients in this category in 2010; 199,934 patients in 2011 and 243,329 patients in 2012. Since the total number of patients attending the hospital facility represents the total population from which referrals (demand) for diagnostic imaging is drawn, the number represents complete population counts hence; no inferential statistical analysis was required, as would be the case if one had been attempting to infer population statistics from sample data. The time series plot and tend analysis was done using Minitab14 statistical software.

RESULTS

Table 1 shows the total procedure volume for diagnostic imaging which stood at 20,612 in 2010; 20,733 in 2011 and 17,826 in 2012. Conventional radiography is the most widely used imaging modality constituting over 50% of the total diagnostic imaging in the three year period. Ultrasound Scanning (USS) is the second most used modality (over 40%) followed by CT (over 2%), MRI and Mammography in that order.

Chest x-ray is the most widely done conventional radiography procedure accounting for 31.44%, 29.69% and 28.86% of the examinations in 2010, 2011 and 2012 respectively.

Table 1: Total Procedure Volume for Diagnostic Imaging

Imaging Procedure	Study Volume 2010	Study Volume 2011	Study Volume 2012
Conventional Radiography			
Chest radiography	6,481 (31.44%)	6,156(29.69%)	5,144 (28.86%)
Abdominal radiography	318 (1.54%)	320 (1.54%)	360 (2.02%)
Skeletal radiography	3,881 (18.83%)	3,815(18.40%)	3,907 (21.92%)
Contrast radiological studies	587 (2.85%)	631(3.04%)	390 (2.19%)
Gastrointestinal fluoroscopy	81 (0.39%)	43 (0.21%)	11 (0.06%)
All conventional radiography	11,348 (55.05%)	10,965(52.88%)	9,812 (55.05%)
Mammography	144 (0.70%)	101 (0.49%)	26 (0.15%)
USS			
General	5,956 (28.90%)	6,389(30.82%)	5,034 (28.24%)
Breast	308 (1.49%)	304 (1.47%)	193 (1.08%)
Obstetric	2,121 (10.29%)	2,377(11.46%)	2,116 (11.87%)
All USS	8,385 (40.68%)	9,070(43.75%)	7,343 (41.19%)
CT			
Cranial	332 (1.61%)	435 (2.10%)	319(1.79%)
Spinal	9 (0.04%)	9 (0.04%)	9 (0.05%)
Body	66 (0.32%)	105 (0.51%)	74 (0.42%)
Musculoskeletal	5 (0.02%)	20 (0.10%)	13 (0.07%)
All CT	412 (2.00%)	569(2.75%)	415 (2.33%)
MRI			
Cranial	88 (0.43%)	8 (0.04%)	93 (0.52%)
Spinal	206 (1.00%)	20 (0.10%)	115 (0.64%)
Body	29 (0.14%)	0	22 (0.12%)
All MRI	323 (1.57%)	28 (0.14%)	230 (1.28%)
Total	**20,612 (100%)**	**20,733 (100%)**	**17,826 (100%)**

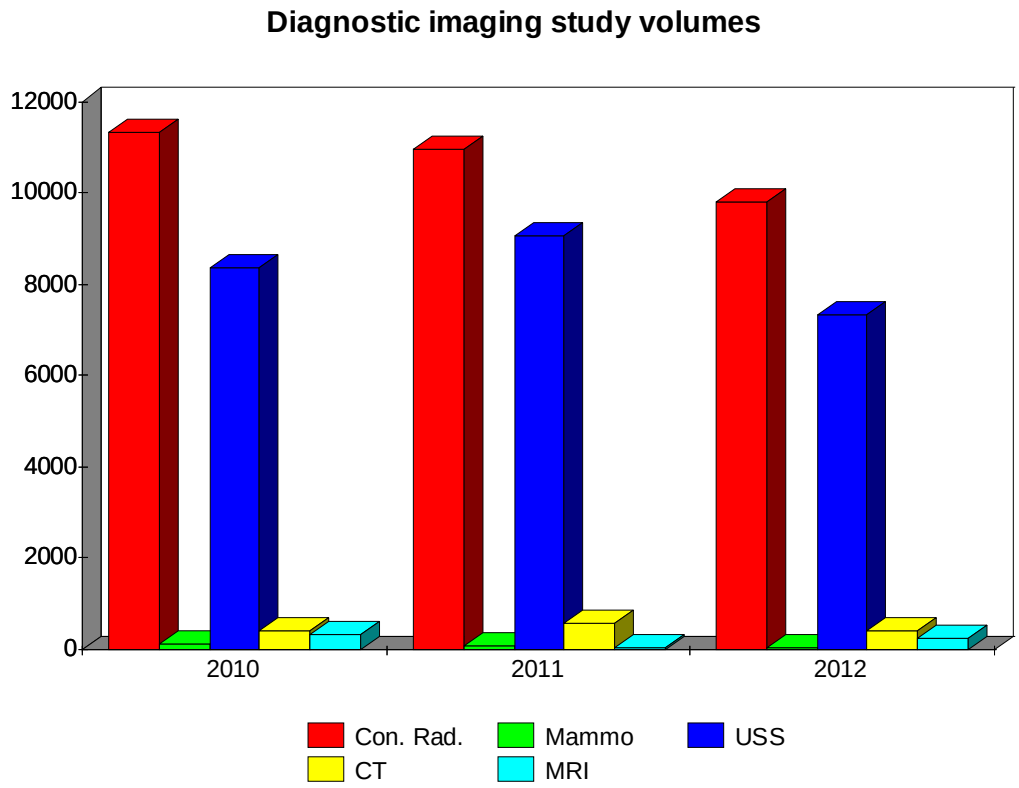

Figure 1: A Graph Showing the Most Frequently Used Imaging Modality in the Diagnostic Imaging Facility

There is a discrepancy noted between the percentages of the professional component RVUs and examination volumes. Although conventional radiography represented 55.05% of all imaging procedures in 2012, RVUs for conventional radiography accounted for only 37.93% of all RVUs in 2012. USS, on the other hand, represented 41.19% of all imaging procedures in 2012 yet corresponded to 55.55% of all RVUs (see table 2).

Table 2: Diagnostic Imaging Workload in RVU

Imaging Procedure	Workload (2010)	Workload (2011)	Workload (2012)
Conventional Radiography			
Chest radiography	7,129.1	6,771.6	5,658.4
Abdominal radiography	381.6	384.0	432
Skeletal radiography	5,795.8	5,734.3	5,826.5
Contrast radiological studies	2,196.1	2,377.3	1,449.8
Gastrointestinal fluoroscopy	188.4	92.2	26.6
All conventional radiography	15,691.0	15,359.4	13,393.3
Mammography	306.4	213.6	58.1
USS			
General	13,112.4	13,578.0	10,648.5
Breast	646.6	786.2	501.8
Obstetric	8,378.0	9,478.0	8,464.0
All USS	22,137.0	23,842.2	19,614.3
CT			
Cranial	1,100.1	1,451.0	1,053.8
Spinal	27.4	26.4	28.8
Body	215.4	337.0	239.8
Musculoskeletal	18.0	61.9	42.4
All CT	1,360.9	1,876.3	1,364.8
MRI			
Cranial	228.8	20.8	241.8
Spinal	1,006.0	96.4	557.6
Body	104.4	0	77.2
All MRI	1,339.2	117.2	876.6
Total	**40,834.5**	**41,408.7**	**35,307.1**

Table 3 shows the hospital's utilization rates for Diagnostic Imaging in 2010, 2011, and 2012, as well as the percentage change in utilization rates between 2010 and 2012. In 2010 the overall diagnostic imaging utilization rate was 908.6 (≅ 909) examinations per 10,000 patients. In 2012 the rate was 732.6 (≅ 733), representing a 19.4% decrease over 3 years.

Table 3: Utilization Rates of Diagnostic Imaging Between 2010 and 2012

Imaging Procedure	Utilization Rates (2010)	Utilization Rates (2011)	Utilization Rates (2012)	% Change b/w 2010 & 2012
Conventional Radiography				
Chest radiography	285.7	307.9	211.4	-26.0
Abdominal radiography	14.0	16.0	14.8	5.7
Skeletal radiography	171.1	190.8	160.6	-6.1
Contrast radiological studies	25.9	31.6	16.0	-38.2
Gastrointestinal fluoroscopy	3.6	2.2	0.5	-81.1
All conventional radiography	500.3	548.5	403.3	-19.4
Mammography	6.3	5.1	1.1	-82.5
USS				
General	262.5	319.6	206.9	-21.2
Breast	13.6	15.2	7.9	-41.9
Obstetric	93.5	118.9	87.0	-7.0
All USS	369.6	453.7	301.8	-18.3
CT				
Cranial	14.6	21.8	13.1	-10.3
Spinal	0.4	0.5	0.4	0
Body	2.9	5.3	3.0	3.4
Musculoskeletal	0.2	1.0	0.5	1.5
All CT	18.1	28.6	17.0	-6.1
MRI				
Cranial	3.9	0.4	3.8	-2.6
Spinal	9.1	1.0	4.7	-48.4
Body	1.3	0	0.9	-30.8
All MRI	14.3	1.4	9.4	-34.3
Total	**908.6**	**1,037.3**	**732.6**	**-19.4**

The table shows a marked decrease in utilization rates between 2010 and 2012. Reductions in examinations per 10,000 patients from 2010 to 2012 were noted in most of the imaging procedures except abdominal radiography (an increase of 5.7%), spinal CT (no increase or decrease), body CT (3.4% increase) and musculoskeletal CT (1.5% increase). Similar reductions were noted for the radiographer's workload except the increase noted for abdominal radiography (13.2%), spinal CT (5.1%), body CT (11.3%) and a marked 135.6% increase for musculoskeletal CT (table 2). Despite the increase in utilization rate of abdominal radiography and spinal, body and musculoskeletal CT, there was a general decrease of 19.4% in utilization rate per 10,000 patients for all the five imaging modalities.

Table 4: Diagnostic Imaging Monthly Study Volume and Utilization Rate Per 10,000 Patients

	Study Volume (2010)	Utilization Rate (2010)	Study Volume (2011)	Utilization Rate (2011)	Study Volume (2012)	Utilization Rate (2012)
JAN.	1,879	82.8	2,053	102.7	1,296	53.3
FEB.	1,939	85.5	1,144	57.2	1,716	70.5
MAR.	2,090	92.1	1,470	73.5	1,872	76.9
APR.	1,954	86.1	1,877	93.9	1,826	75.0
MAY	1,714	75.5	1,555	77.8	1,299	53.4
JUN.	1,118	49.3	2,208	110.4	1,578	64.9
JUL.	508	22.4	1,852	92.6	1,464	60.2
AUG.	1,983	87.4	1,826	91.3	1,486	61.1
SEPT.	1,919	84.6	1,552	77.6	1,272	52.3
OCT.	2,005	88.4	1,988	99.4	745	30.6
NOV.	1,841	81.1	1,691	84.6	1,785	73.4
DEC.	1,662	73.3	1,517	75.9	1,487	61.1

Figure 2 shows the time series plot of the monthly utilization rate of diagnostic imaging per 10,000 patients and the trend line. The trend line shows a decrease in utilization rate over the period studied.

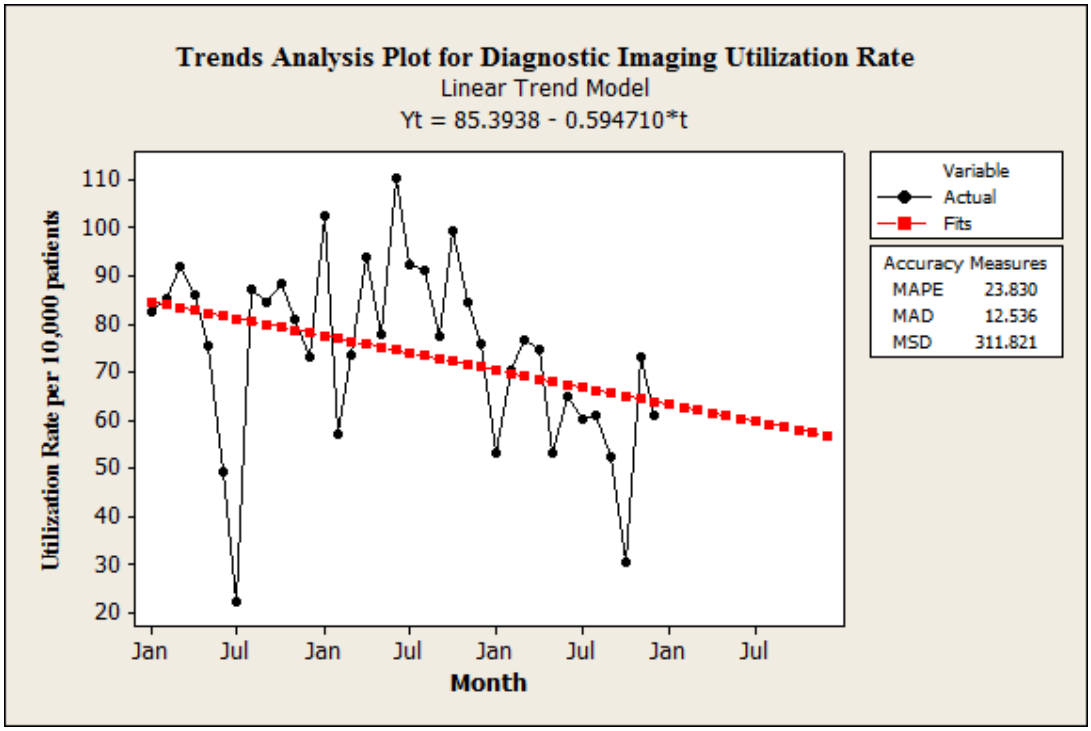

Figure 2: Time Series Plot of Diagnostic Imaging Utilization Rate Per 10,000 Patients Showing the Trend Line

DISCUSSION

In the 3 years studied, conventional radiography remained the most commonly performed type of examination and was utilized more than all other types of examinations. Although conventional radiography accounted for over 50% of all diagnostic imaging procedures, its RVU was less than 39% of all RVUs in the 3 years of study, indicating that the majority of the diagnostic imaging examinations do not account for the majority of the work. This is in agreement with earlier studies [10]. Between 2010 and 2012, the overall utilization rate of diagnostic imaging decreased by 19.4%. A linear model fitted to the time series plot showed a slow and steady drop in the utilization of diagnostic imaging between 2010 and 2012 (see figure 2). However, a quadratic model fitted to the time series plot in figure 3 gives a better picture of the utilization of diagnostic imaging between 2010 and 2012 as it clearly demonstrates a gradual rise in utilization rate from 2010 to 2011 and a slow and steady fall in utilization rate from 2011 to 2012. This also agrees with another study reported in the literature [12].

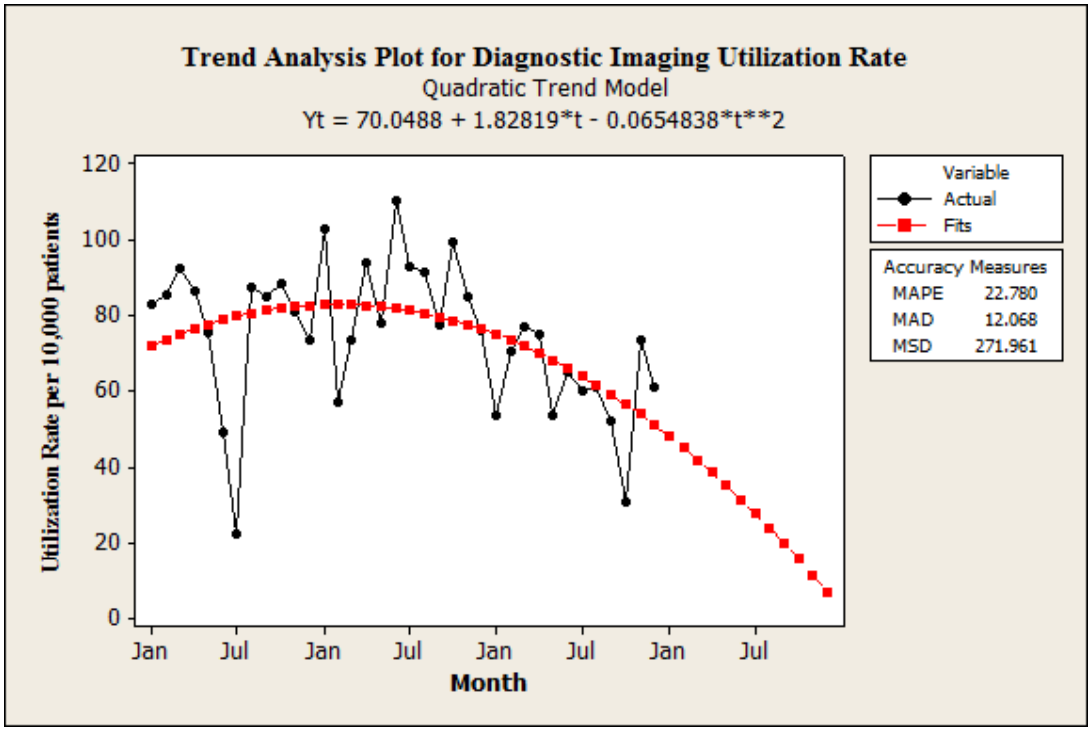

Figure 3: Time Series Plot of Diagnostic Imaging Utilization Rate Per 10,000 Patients Showing the Trend Curve

This steady drop may suggest that physicians in the hospital are not increasing their utilization of diagnostic imaging but, that is not the case. Rather, it is the fact that diagnostic imaging equipments break down for long periods before they are rectified and put back to use. Records available in the facility we studied show that the CT equipment broke down for 50% of the time in 2010, 25% of the time in 2011, and 8.3% of the time in 2012. The MR scanner broke down for 8% of the time in 2010, 75% of the time in 2011, and 25% of the time in 2012. The Mammography equipment broke down for 16.7% of the time in 2010, 25% of the time in 2011, and 50% of the time in 2012. The fluoroscopy equipment (the screening unit) broke down for 2% of the time in 2010, 33.3% of the time in 2011, and 50% of the time in 2012. During this time of equipment break downs, patients look outside for help. Secondly, the department is run by appointment system since it cannot cope with the daily demand for diagnostic imaging. Patients who cannot endure the few days appointment often seek help outside the hospital. It is obvious therefore, that the issue here is more of inaccessibility of services

than a drop in demand for diagnostic imaging services.

CONCLUSION

It has been established, from this study that equipments breakdown have great influence on utilization rate of diagnostic imaging. From the results one can conclude that some of the imaging modalities have not been put to use optimally and have not justified government spending on them particularly, CT, MRI, and Mammography.

In order to achieve clinical and economic effectiveness, effort must be made to ensure optimal utilization of diagnostic imaging. All hands must be on deck to ensure regular service maintenance of all imaging equipments, and prompt actions should be taken to effect repair of broken down equipments. Health policy makers should begin to consider, with all seriousness, the issue of capacity building in health/medical equipment maintenance engineering in order to forestall the current trend of incessant equipment breakdowns, long breakdown time, and dumping of failed medical equipments that abound in the health system nationwide.

REFERENCES

1. Arimie, C.O.D (2012). Managing Medical Equipment Procurement and Maintenance for Sustainable Healthcare Development. *Journal of Medical and Biological Sciences.* Vol. 2, No. 2: 1 - 9. Insuderc Academic Publishers.

2. Arimie, C.O.D. and Agi, C.E. (2010). Economic Evaluation of Computed Tomography in a Teaching Hospital. *Kanem Journal of Medical Sciences.* 4(1): 19 - 24.

3. Measuring Consultant Radiologists Workload in Ireland. Available at (http://www.radiology.ie/wp-content). Accessed on 22/8/2013.

4. Fisher, H.W. (1982). Radiology Departments: Planning, Operation and Management. Author, pp 45.

5. Stockburger, W.T. (1989). Radiology Administration: A Business Guide. *J.B. Lippincott Company,* Philadelphia. 33 - 55.

6. Shapro, H.R. (1987). "Relative Value Accountability". Administrative Radiology. 47 - 50.

7. Mezrich, R. and Nagi, P. G. (2007). The Academic RVU: A System for Measuring Academic Productivity. *Journal of the American College of Radiology.* 4(7): 471 - 478.

8. Pitman, A.G. and Jones, D.N. (2006). Radiologists Workloads in Teaching Hospital Departments: Measuring the workload. Royal Australian and New Zealand College of Radiologists. 50: 12 - 20.

9. Burkhardt, J.H. and Sunshine, J.H. (1996). Utilization of Radiologic Services in Different Payment System and Patient Population. Radiology. 200: 201- 207.

10. Maitino, A.J., Levin, D.C., Parker, L., Rao, V.M. and Sunshine, J.H. (2003). Nationwide Trends in Rates of Utilization of Noninvasive Diagnostic Imaging Among the Medicare Population Between 1993 and 1999. Radiology. 227(1): 113 - 117.

11. Burkhardt, J.H. and Sunshine, J.H. (2001). Radiology Groups' Workload in Relative Value Units and Factors Affecting It (Letter). Radiology. 218: 602.

12. Smith-Bindman, R., Miglioretti, D.L., Johnson, E. *et al.,* (2012). Use of Diagnostic Imaging Studies and Associated Radiation Exposure for Patients Enrolled in Large Integrated Healthcare Systems, 1996 - 2010. JAMA. Vol. 307 No. 22. Available At (jama.jamanetwork.com/article). Accessed on 20/9/2013.

Reference to this paper should be made as follows: Arimie C.O.D. (2013), Trends in Diagnostic Imaging Workload and Utilization in a Teaching Hospital. *J. of Medical and Applied Biosciences,* Vol. 5, No. 2, Pp. 19 – 31.

Biographical Note: Christopher Onyema ARIMIE is the Chief Medical Imaging Scientist/Radiographer at the Radiology Department of the University of Port Harcourt Teaching Hospital, Port Harcourt. He holds the Diploma of the College of Radiographers (DCR), London, B.Sc. in Management, Post Graduate Diploma (PGD) in Statistics, and M.Sc. in Applied Mathematics specializing in Operations Research and Optimization. He is currently a Ph.D student in the Department of Mathematics & Statistics, University of Port Harcourt. He is a member of the Association of Radiographers of Nigeria. He has published papers in reputable academic journals. His research interests include Mathematical modeling of healthcare systems, Operations Research and Optimization.