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Evaluation of the Downtime of Radiological Equipment in Kano Metropolis, Nigeria

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Abstract
Radiology equipment should have minimal downtime and provide outputs of high reliability to ensure prompt and accurate diagnosis. Prolonged downtime affects the moral, productivity of radiographers, radiologists and patients are unduly delayed in accessing radiological services. The study was aimed at evaluating the downtime of the radiological equipment in Kano metropolis, Nigeria. The study design was retrospective conducted in some selected hospitals and a private center in the Kano metropolis from April 2019 to November 2019. An ethical approval to conduct the study was obtained from the Human Research and Ethics Committee of the Kano State Ministry of Health. Purposive sampling method was used in selecting the hospitals and the private center. The model, year of installation and the downtime obtained from the records of all the selected equipment was recorded on the data capture sheet. Center I had the highest frequency of equipment breakdown (5times) while center IV and VI had the lowest frequency of breakdown (once). The equipment with the most prolonged and second most prolonged was found in Center IV (10years, 6months and 7years, 3 months). The equipment with the shortest downtime was found in Center II (1day) and the second shortest was found in Center III and VI (1week) each. X-ray machines had the most prolonged downtime followed by CT. MRI had the shortest downtime. Radiological equipment in Kano metropolis is associated with frequent breakdown and prolonged downtime.

Keywords: Downtime, Radiological Equipment, Kano metropolis.

INTRODUCTION
Equipment is an integral part of the physical infrastructure of a hospital setup; it is an important means of providing various diagnostic and therapeutic services to the people and account for a major share of any hospital's budget (Nzota *et al*., 2014). The increased sophistication of modern radiology equipment came with reduced size, improved diagnostic accuracy and speed, but no corresponding guarantee of durability or reliability. "Catastrophes" such as component failure, significant component deterioration, human error and maintainable faults may result if quality control checks, planned preventive measures and an attitude of prompt repairs are not in place (Agwu and Okeji, 2009). Normal wear and tear of equipment, while it is being used for its intended purpose, contributes to increasing periods of down-time. Functional equipment failure

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refers to the inability of the equipment to perform its required function within specific limits of performance, which may be due to deterioration or breakdown of certain components that make up the equipment. According to statistics on medical equipment failures, about 80% of all failure cases are caused by preventable factors. For instance, failures due to inadequate maintenance account for about 60% of all the failure cases. In this case, most failures arise from deterioration of accessories and consumable components. The deterioration time of the accessories and consumable components can, however, be predicted by carrying out maintenance and inspection (Okeji *et al*., 2012).

Downtime (DT) is defined as the time during which equipment assigned to perform a specific function is not available because of breakdown (Elazouni & Basha, 1996). The main challenge with equipment breakdown is how to reduce the frequency of breakdown and minimize equipment breakdown. A well equipped radiology department with adequate staff mix ensures prompt and accurate diagnosis, discourages referrals and provides opportunities for Resident Doctors, Medical and Radiography Students to learn and carry out research. These goals are often encumbered by increased downtime of the equipment. Since radiological equipments are very expensive to procure and maintain, this could also explain the high rate of equipment breakdown and prolonged downtime observed in various centers, as hospital managements tend to abandon some equipment when they are faced with the high cost of maintenance and repairs. Since most equipment fault can be predictable, well planned procurement pattern, planned preventive maintenance, quality control and prompt repairs are essential for effective and efficient radiological practice as well as increasing the lifespan (Nwobi *et al*., 2020). Radiology equipments should have minimal downtime and provide outputs of high reliability to ensure prompt and accurate diagnosis. Empirical study shows that radiology equipments in some centers are characterized by incessant breakdown and often, with prolonged downtime. This situation affects the moral and productivity of radiographers and radiologists. To the best knowledge of the researchers there was no documented work on the evaluation of the downtime of the radiological equipment in Kano metropolis. Furthermore, there was a paucity of data similar or related to the current study worldwide. The patients are unduly delayed in accessing radiological services. The findings of the study are expected to serve as a guide to the managements of the radiological facilities in Kano metropolis in policy formulation and strategic planning that would minimize downtime, optimize availability and perhaps, position the radiology department to render uninterrupted and dedicated services to humanity. The study was aimed at evaluating the downtime of the radiological equipment in Kano metropolis.

MATERIALS AND METHODS

The study design was retrospective conducted in some selected hospitals and a private center; two federal government hospitals, three state government specialist hospitals and one private diagnostic center in the Kano metropolis from April 2019 to November 2019. An ethical approval to conduct the study was obtained from the Human Research and Ethics Committee of the Kano State Ministry of Health. Purposive sampling method was used in selecting the hospitals and the private center; the hospitals and private center were named center I – VI. The hospitals and private center with radiological equipment and agreed to participate were included in the study while those without radiological equipment, did not agree to participate or had no traceable records were excluded from the study. In the selected hospitals and the private center; any equipment without record of its installation date, breakdown and repair or has never breakdown since installation was excluded from

the study. The model, year of installation and the downtime obtained from the records of all the selected equipment were recorded on the data capture sheet.

RESULTS

Center I

A total of thirty-two equipment were found, twenty eight were installed and only six were found to have traceable records of downtime. Mammography machine had 5 downtimes and each lasted for two months, CT scanner also had 5 downtimes; the longest downtime was 7 months and the shortest was 2months. Static x-ray machine had two downtimes of 2 months and 1 month, direct digital static x-ray unit also had 2 downtimes of 8 months and 2 months, angiography and fluoroscopy each had a single down time of 2 years and 8 months and 3 months.

Table 1: Equipment downtime for center I

Equipment	Year of Installation	Downtime				
		1	2	3	4	5
Mammograph t-plus (turGermany)	2005	30/6/2014 - 1/9/2014 (2ms)	9/11/2015 - 6/1/2016 (2ms)	6/3/2017 - 1/5/2017 (2ms)	16/8/2017 - 19/10/2017 (2ms)	13/4/2018 -6/6/2018 (2ms)
4 slice GE CT Scanner	2012	13/11/2014 -4/2/2015 (2ms&3ws)	2/3/2016 -14/6/2016 (3ms)	10/8/2017 -21/10/2017 (2ms)	19/3/2018 - 3/10/2018 (7ms)	12/12/2018 -6/6/19 (6ms)
Ge 500ma static X-ray	1996	12/8/2006 -5/10/2006 (2ms)	25/6/2008 -1/7/2008 (1m)			
Direct digital static X-ray unit	2014	13/12/2014 -14/01/2017 (2ms)	17/1/2019 -30/09/2019 (8ms)			
Angiography (inno va-3100) G.E vamed	2009	8/1/2017 -30/09/2019 (2ys&8ms)				
Static Fluoroscopy (GE Vamed)	2009	26/06/ 2019 -30/09/2019 (3ms)				

Key: d=day, ds=days, w=week, ws=weeks, m=month, ms=months, y=year, ys=years, -=to

Center II

A total of seven installed equipment with four had traceable records. MRI scanner had 4 downtimes; the longest was 1 month and 22 days and the shortest was 1 day, CT scanner had 2 downtimes of 4 months and 2 months. The mammography and x-ray machine each had a single downtime of 1 month and 2 years.

Table 2: Equipment downtime for center II

Equipment	Year of Instillation	Downtime			
		1	2	3	4
Signa Creator 1.5T MRI NG1333MR01	2017	11/12/2018 -18/12/2018 (7ds)	18/4/2019 -19/4/2019 (1d)	18/5/2019 -9/7/2019 (1m&22ds)	7/9/2019 -5/10/2019 (1m)
CT scan	2017	10/10/2018 -5/2/2019 (4ms)	31/7/2019 -5/10/2019 (2ms)		
Seno Essential *Mammography*	2017	26/08/2019 -30/09/2019 (1m)			
Shimadzu –Rad speed X-ray machine	2017	8/7/2017 -8/7/2019 (2 ys)			

Key: d=day, ds=days, w=week, ws=weeks, m=month, ms=months, y=year, ys=years, -=to

Center III

A total of six installed equipment and four had traceable records. Two out of the 3 x-ray machines, each had single downtime of 2 years and 5 years, whereas the third x-ray machine had 2 downtimes of 1 year and 5 years. The ultrasound machine had a single downtime of 1 week.

Table 3: Equipment downtime for center III

Equipment	Year of Instillation	Downtime	
		1	2
Medicor budapest X-ray machine	1993	12/2/2001 -2/7/2003 (2ys)	
Equipprep S.A X-ray machine	1991	12/3/2009 -10/2/2010 (1y)	12/1/2014 -30/9/2019 (5ys)
X-ray Corsix-e 110 Halray	2000	5/8/2014 -30/9/2019 **(**5ys**)**	
Table Top Ultra Sound Machine (Philips)	2012	23/11/2017 -30/11/2017 (1 w)	

Key: d=day, ds=days, w=week, ws=weeks, m=month, ms=months, y=year, ys=years, -=to

Center IV

A total of ten installed equipment and five had traceable records. Each equipment in the center had a single downtime; the longest downtime was 10 years and 6months while the shortest downtime 6 months.

Table 4: Equipment downtime for center IV

Equipment	Year of Installation	Downtime 1
Gec medical Roentgen 501 static X-ray	1973	2/4/ 2009 -8/10/2019 (10ys&6ms)
Gulfex model f100 mobile X-ray	2011	12/6/ 2012 -10/9/ 2019 (7ys&ms)
Halray pixel hf650	2006	6/1/ 2010 -1/2/2011 (1y, 1m)
Italray Mammograph	2014	28/12/2015 -2/8/2019 (4ys, 7ms)
Medicor Budapest Static X-ray Machine	1979	12/7/2011 -10/1/2012 (6ms)

Key: d=day, ds=days, w=week, ws=weeks, m=month, ms=months, y=year, ys=years, -=to

Center V

A total of seven installed equipment was found and three had traceable records. One out of the 3 x-ray machines had 3 downtimes of 1 month and 3 weeks each for the other 2 downtimes; the other 2 machines each had a single downtime of 2 years.

Table 5: Equipment downtime for center V

Equipment	Year of Instillation	Downtime 1	2	3
GE floor mounted x-ray machine	2010	3/5/2018 -1/6/2018 (1m)	1/9/2019 -23/9/2019 (3ws)	2/10/2019 -23/10/2019 (3ws)
Rex-650r static x-ray 06-0234	2010	20/2/2017 -3/2/2019 (2ys)		
Mobile x-ray hm32	2012	6/6/2017 -10/6/2019 (2ys)		

Key: d=day, ds=days, w=week, ws=weeks, m=month, ms=months, y=year, ys=years, -=to

Center VI

A total of three was found and two had traceable records. The x-ray machine had a single downtime for one week only; the CT scanner also had a single downtime of 5 years and 4 months.

Table 6: Equipment downtime for center VI

Equipment	Year of Installation	Downtime
		1
Shimadzu x-ray machine 74002	2015	5/12/2015 -12/12/2015 (1w)
Hitachi CT scanner 160 slice	2014	6/6/2014 -10/10/2019 (5ys & 4ms)

Key: d=day, ds=days, w=week, ws=weeks, m=month, ms=months, y=year, ys=years, -=to

DISCUSSION

The findings of the study show in the Center I CT scanner and the mammography machine had the highest frequency of broken down; 5 times each of the installation (2006) to October 2019, followed by the static x-ray machine and direct digital x-ray machine each with a history of broken down twice, fluoroscopy and angiography machines had the lowest frequency; each broken down once as shown in table 1. However, angiography had the longest downtime (2year, 8months) and mammography machine had the lowest (2months) in the center as shown in table 1. The angiography machine is the only machine in the entire North-West and North-Central regions of Nigeria, patients have to travel from these regions of the country to other regions for angiography procedures. This causes more stress to the patients and their relatives, additional cost to the patients, affects the moral of the staffs operating the equipment, and decreases the income and efficiency of the facility. The fluoroscopy machine had second longest downtime (9months), it is the only fluoroscopic machine in the center; by implication the procedure that was supposed to be performed under fluoroscopy had to be performed blindly which will certainly have a negative impact on the moral of the staffs operating the facility and the efficiency of the facility. Despite the fact, mammography had the lowest downtime of 2months, being the only machine in the center, the frequent broken down of the equipment will certainly affect the moral of the staffs operating the machine and decrease the efficiency of the facility. The findings of the study also show that in Center II all the equipment were installed in 2017. The MRI scanner had the most frequent history of breaking down (4 times), followed by CT scanner (twice), and then conventional x-ray and mammography machines had the least history of broken down (once each) as shown in table 2. However, the conventional x-ray machine had the longest downtime (2years), it has been down since installation. This is as a result of software incompatibility that has not been addressed up to this time, followed by the CT scanner (4 months), and then the MRI scanner (1month, 22days) as shown in table 2. By implication, it is the only MRI scanner that is owned by the State Government and the cost of performing the procedure is moderate compared to private radiodiagnostic centres. Therefore, patients

referred to the state government hospital have no option than to go and do the examination at a higher cost. Furthermore, the prolonged downtime will have a negative impact on the income of the management and the moral of the personnel managing the equipment. The findings of the study also show that in Center III there were only x-ray machines and an ultrasound machine. The oldest x-ray machine had the most frequent broke down (twice) and installed since 1991. The downtime of the x-ray equipment in the center ranged from 2years to 5years, and the oldest machine had the longest downtime (5years) as shown in table 3. However, the ultrasound machine had the shortest downtime (7days) as shown in table 3, and is considered reasonable downtime for radiological equipment. Furthermore, the findings of the study show that in Center IV all the equipment had the same history of broken down (once) for each of the equipment and the downtime ranged from 6months to 10years and 6months. The oldest machine installed since 1973 in the center was a static x-ray machine, and it had the longest downtime (10years and 6months) followed by a mobile x-ray machine (7years and 3months), another x-ray machine had the lowest downtime as shown in table 4. The center has the highest patient's turnout in the entire Kano metropolis; therefore longer downtime encountered with the x-ray equipment will certainly affect the moral of the personnel operating the equipment and also affect the efficiency of the facility. The findings of the study also show that in Center V the GE floor mounted x-ray had the highest frequency of broken down (3 times), while the other two x-ray machines each had a history of broken down once as shown in table 5. However, the machine with the history of the most frequently broken down had the shortest downtime (had 3 downtimes; of 1 month and 3 weeks each for the other 2 downtimes), while the other two machines with a history of broken down once had the longest downtime (2years each) as shown in table 5. The center is the only government own orthopedic specialist hospital in the entire northern Nigeria. Almost all the patients attending the center will certainly require x-ray examination; therefore having longer downtime will affect both the moral of the staffs operating the equipment and the efficiency of the facility. The findings of the study also show that in Center VI, the two equipments in the center had the same frequency of broke down; however the CT scanner had the longest downtime (5years and 4months) since the instillation of the equipment as shown in table 6. The x-ray equipment had a history of downtime of only one week. The center is a private radio-diagnostic; CT scanner is very expensive to instill and since the instillation the equipment has not been; this will certainly affect the moral of the investors and the staffs employed to manage the equipment.

CONCLUSION

Radiological equipment in Kano metropolis is associated with frequent breakdown and prolonged downtime.

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