Original Article :

Modify approach for Radiology utilization rate calculation in emergency Department at Saudi Arabia.

Mohamed Ibrahem Waly

Associate Professor, Department of Medical Equipment Technology, College of Applied Medical Sciences, Majmaah University, Al Majmaah 11952, Saudi Arabia

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Corresponding author:
Mohamed Ibrahem Waly
Department of Medical Equipment Technology, College of Applied Medical Sciences, Majmaah University, Al Majmaah 11952, Saudi Arabia, email address: m.waly@mu.edu.sa

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Abstract

Background and Aims:
Healthcare debates emphasize optimizing costly imaging equipment use (e.g., CT, X-rays) contributing significantly to expenses. This study assessed American and Canadian utilization techniques, integrating a modified equation. Objectives were to aid decision-makers in evaluating current equipment use and refining equations for better efficiency.

Methods:
Data collection and analysis evaluated current utilization approaches. Comparative analysis using the modified equation highlighted differences between American and Canadian standards, offering insights for improvement.

Results:
Findings revealed disparities in techniques used in both healthcare systems. The modified equation enabled a detailed comparison, pinpointing areas for enhancement. Decision-makers gained a comprehensive understanding of equipment usage, identifying avenues for efficiency and resource optimization.

Conclusions:
The study underscores the necessity of reassessing and refining utilization equations for expensive medical equipment. Insights provided a roadmap for decision-makers, enabling them to implement strategies enhancing efficiency and maximizing resource potential. By aiming for more effective utilization, healthcare systems can navigate challenges posed by costly imaging equipment, ultimately advancing healthcare quality and accessibility.

Keywords:
Utilization, Capital Medical Equipment, Emergency Department, Diagnostic Medical Imaging Equipment.

Introduction

One of the reasons for improving human life in medicine is the advancement in the field of medical sciences and its applications in both diagnosis and treatment by using modern technologies and hi-tech medical equipment. There are many varieties - or modalities - of medical imaging procedures, every of that uses completely different technologies and techniques, most of these techniques are made through ionizing radiation to produce medical images of the patient's organs. Medical imaging has contributed to improved and accelerated diagnosis and treatment for various medical conditions in children and adults.[1]

The importance of useful utilization rate (UR) for medical imaging equipment in the emergency department (ED) has been increased in health care providers/paramedic.[2,3,4] Further, the decision of diagnoses and admission in ED changes frequently by physicians after using the diagnostic medical imaging equipment, especially computed tomography (CT scanner).[5] One of the reasons why medical imaging is a need in ED is that medical staff need a quick and accurate diagnosis at the same time, and thus led them to make decisions as quickly as possible.[6,7]

About the body organs that have been increased photography in the past two decades is the chest, whereas during the year 2000 to 2008, the highest photograph was the head CT. [8,9,10] Hence, the concept of optimal use has become more critical. Many international institutes and organizations have defined utilization as ‘’the effective use of a property[11], health care service ware provided under conditions in which its possibility for injury exceeds the possible benefits for a patient, underuse is the inability to use a health care service that may have been needful for a patient.[12] In addition the optimal usage of medical equipment reduces the institute budget. [13] It helps decision maker for buying new devices/equipment or staying the current situation until they are optimal used [14].

International organization's recommendations for diagnostic medical imaging equipment (DMIE) utilization are starting from 50% such as, Medicare Payment Advisory Commission (MedPAC). Whereas the (MedPAC), recommends utilizing up to 50% that was in 2006, and they increase the percentage in 2009 up to 90% [15]. The Patient Protection and Affordable Care Act (PPACA) recommend utilizing medical equipment up to 75% that was in 201016. Furthermore, Centers for Medicare and Medicaid Services (CMS), which administers the health assistance program proposes to be not only utilized 50 % but presumably increase to be 90 % this was in 2009

when the (Philips) company responded to it by not raise staying at the current rate. [17] Subsequently, Siemens Medical Solutions recommends utilizing medical equipment up to 75% that was in 2012. [18] In 2015, CMS issued an assumption that the rate of utilization of medical imaging equipment increases to not only 50 %, but reaches 70 %, this assumption will be applying after two years, and that by 2017 [19]. Many researchers they are developing techniques to calculate utilization rate based on two main methods:

First method based on American stander by Medicare Payment Advisory Commission (MedPAC):

$$UR = W/3000 \qquad (1)$$

Where UR is the utilization rate, W is the actual number of weekly minutes used and 3000 refers to the total actual [50 hours per week * 60 minutes per hour]).

Many researchers applied this equation, David A. Butz and David W. Lee found the average rates were 73% for CT scanner, which is in the range of (PPACA).[20] Many researchers conducted it on different types of medical devices where the measurement of utilization is not limited to high-cost medical devices [22,23,24]. Taghipour, S and et al. in 2010 Use the calculation of equipment utilization to prioritization of different types of medical devices, as well as the level of risk criteria, results ranges were from high to low[21]. Chaudhary et al., in 2012, conducted a study on 50 Diagnostic equipment; the result was 60.2%; this means that these establishments have invested the equipment well [22]. They also conduct another utilization study; especially for Histopathology department and the medical equipment, the study showed that the equipment was not used in the required form as the results are only 23%.[23]

While Gupta et al. applied dental medical equipment to assess the coefficient of utilization; they found the rate of utilization is 50% [24].

Second method based on Canadian stander by Canadian Association of Radiologists (CAR) [25], relationship between a lifetime of medical equipment and utilization best on the number of exams per year (Table 1).

Table 1. Medical imaging equipment utilization guidance

	Utilization based on exams / year		
Device Name	HIGH	MID	LOW
Radiographic systems, digital (X-Ray)	> 20,000	10,000 – 20,000	< 10,000
Radiographic unit, digital (Mobile X-Ray)	> 6,000	3,000 – 6,000	< 3,000
CT scanner	> 15 000	7,500 – 15,000	< 7,500

Many researchers have been used the second method based on this CAR stander, which depend on the calculation of the number of exams in diagnostic medical imaging equipment. In 2011, an audit assessment of the hospital in Germany and European it was for Magnetic Resonance Imaging (MRI) equipment, all result was above 40% [26]. Nikhil a Mathew and et al. in Jan 2014 up to Mar 2016 an audit study and assessment the utilization and quality assurance of equipment in MS Ramaiah Memorial hospital Bangalore it was for three medical imaging equipment Mammography, MRI and CT scanner, it was found that equipment utilization and quality assurance are closely related [27]. In 2018, The World Health Organization (WHO) conducted a study in Europe for high-value capital medical equipment, the result of CT scanner less than 3000 exams per year, which is mean low utilization [28].

The aim of this study to provide a simply implemented method for radiology utilization rate calculation in Saudi Arabia based on integrated variables like downtime of devices, whether corrective or scheduled maintenance and working hours in the emergency department reflecting the reality of UR.

Materials and methods

The retrospective study was performed at two hospitals; one is government, and the other is private, where the size of each hospital is 800 beds, contains several medical specialties. All radiological image examinations presented to ED collected from January 1, 2016, to December 31, 2018, were included. The American and Canadian standards were applied on Government hospital; while the Canadian standard was applied only on the private hospital this is due to lack of information that can be used to apply the American stander.

The collected data regarding radiation imaging use from the health information system (HIS), ware categorized type of device used to take the image exams, whether computed tomography (CT scanner), radiographic systems, digital (X-Ray) and the radiographic unit, digital (Mobile X-Ray). Also, the collected data contains the procedure type, starting, and ending time, concerning maintenance data, both scheduled and not scheduled maintenance, device cost, and purchase data as history; most of these data will help in calculating modified approach.

The modified approach equation is:

$$AUR = AUT / AAT \qquad (2)$$

Where AUR is actual utilization rate, AUT is the average number of used time per week [Total used time per year ÷ 52 weeks], AAT is average available time

weekly minutes after subtracting the down-time, the fixed numbers 525600 minute in year [where 24 hour * 60 minutes = 1440 minute in day, 1440 min * 365 day in year =525600] number of week per year is 52 weeks.

The results from the modified approach compared with the American approach, and the Canadian approach.

Results

Table 2 summarizes the sample of data collection: patient numbers, year of imaging, type of medical device used CT scanner, X-Ray and Mobile X-Ray, name of body organ used in the procedure and the start and end of the procedure.

Table 3 summarizes each medical procedure that was calculated for each week and repeated for three years and for three devices as number of exams. Table 4 shows the sample of the average time used by minutes; this step repeated for each machine during the three years.

TABLE 2: Sample of Data Collection

No.	Year	WORKPLACE GROUP	PROCEDURE NAME	PROCEDURE START	PROCEDURE END	Month	Wee.O
27	2016	ER_CT	BRAIN	2016-01-01 02:44:00	2016-01-01 03:04:00	Jan	1
132	2016	ER_X-ray	Fingers (right and left)	2016-01-02 07:02:00	2016-01-02 07:04:00	Feb	1
72221	2017	ER_X-ray	KUB (kidneys, ureters, bladder)	2017-12-01 17:34:00	2017-12-01 17:41:00	Dec	48
75866	2018	ER_X-ray	Abdomen (Total)	2018-01-03 12:15:00	2018-01-03 12:21:00	Jan	1
75869	2018	PORTABLE	Abdomen (Total)	2018-01-03 17:35:00	2018-01-03 17:41:00	Jan	1
75870	2018	ER_CT	Brain	2018-01-01 08:38:00	2018-01-01 08:58:00	Jan	1

Table 3. Number of Repetition Procedure per Week

Row Labels	1	2	3	4	5	6	7	8	9	10	11	12	13	53	Grand Total
Abdomen (Total)	200	225	200	225	200	200	275	225	300	200	275	200	200	375	535
Abdomen Angiogram	0	0	0	0	30	0	0	0	0	0	0	0	0	0	10
Ankle	0	0	0	0	0	20	0	[illegible]					0	0	24
Brain	24[illegible]		560	1040	640	660	[illegible]						0	920	2023
Brain & Neck			0	25	0	25							0	0	23
Brain & Orbit			0	25	25	0							0	0	30
Brain & Para Nasal Sinuses			0	0	0	25	0	25	0	0	0	25	25	0	14
Brain Angiography of the Circle of Willis	3		60	0	0	0	0	60	0	0	0	0	0	0	20
chest Angiogram			125	125	25	100	25	75	50	0	75	75	25	100	141
Chest, Abdomen and Leg			0	0	0	0	0	0	0	0	0	0	0	0	1
CT Other Specify Area			0	0	0	0	0	0	0	0	0	0	0	0	6
CT Urography (CTU)			25	0	0	0	0	0	0	0	0	0	0	0	4
Elbows			0	0	0	0	0	0	20	20	20	0	0	0	21
Facial Bones			0	40	0	0	0	0	0	20	20	0	0	40	23
Feet (Both, Rt. & Lt.)			0	0	20	0	0	0	0	0	0	0	0	0	8
Femur (Both, Rt. & Lt.)			0	0	0	0	0	0	0	0	0	0	0	0	1
Hand Rt & LT			0	0	0	20	20	0	0	0	0	0	0	0	8
Hips (Both RT & LT)	0		0	0	20	0	20	0	0	20	0	0	0	0	7
Humerus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
kidneys	40	180	240	200	160	200	240	100	120	240	160	260	240	480	645
Trauma Survey Brain Facial Bone	30	30	30	0	0	30	0	0	0	0	0	30	0	0	19
Upper Extremity Angiogram	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Wrists	0	20	0	20	20	40	20	20	40	0	20	40	0	20	37
Grand Total	590	1685	1575	2070	1590	1740	1915	1885	1730	1740	1630	1960	1645	2245	

Number of weeks

Name of procedure

Table 4 shows the sample of the average time used by minutes; this step repeated for each machine during the three years.

Test Protocol Type	Weeks number (MIN)				
	1	2	3	4	5
Abdomen (Total)	96	126	120	246	150
Ankle	9	108	81	48	75
Bone Survey	0	0	25	0	25
Both Hip CDH	0	0	0	0	0
Both Hips (RT. & LT. Hip)	0	20	40	25	25
Cervical Spine	12	48	42	54	60
Chest (Pa only, Ap, Pa & Lat, Insp. Exp.)	150	390	374	442	374
Chest and Abdomen	12	24	24	36	30
Chest for Ribs	0	0	12	30	6

Downtime was calculated by the maintenance report through biomedical engineer, the calculations were performed from maintenance data both scheduled and not scheduled maintenance.

First calculated data based on the Canadian way, fined the medical imaging increased during the three years and became noticeable in government hospital (Figure 1), and this confirms that the use of CT scanner in ED increased by the health care providers It has also been proven by research conducted in the United States of America [2, 3, 4]. However, in a private hospital, the X-Ray medical imaging is increased while the medical imaging by CT scanner oscillatory between 5220 exams up to 5677 exams during those three years (Figure 1). Second calculated data based on the MedPAC way equation (1), this equation can give inaccurate results. Also, the rate of CT scanner utilization in the last year is higher than 100%, according to the study statistics, which contradicts the actual situation. In addition, the study shows that X-Ray has utilized over the manufacturer recommended rate (Siemens, Philips) (Figure 2). However, while it used equation is modified with the consideration of the equipment availability after it subtracts the downtime and actual working hours, the results are completely accurate and identical to the actual utilization (Figure3).

In the (Figure 4) shows the comparison between the two equations whereas (Figure 5) shows the study results in comparison to the international recommendations (mentioned above).

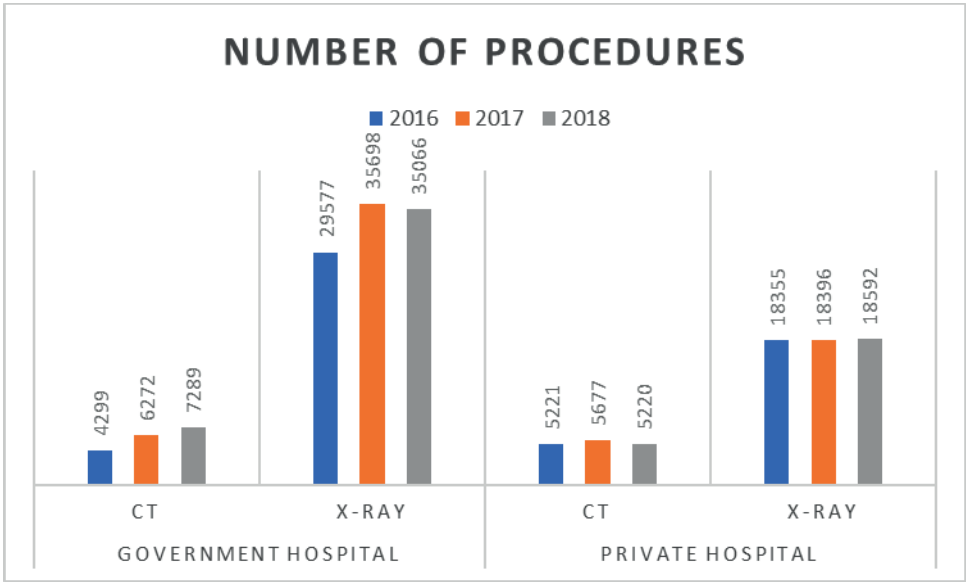


Figure 1. Number of Procedures in Government and Private Hospital

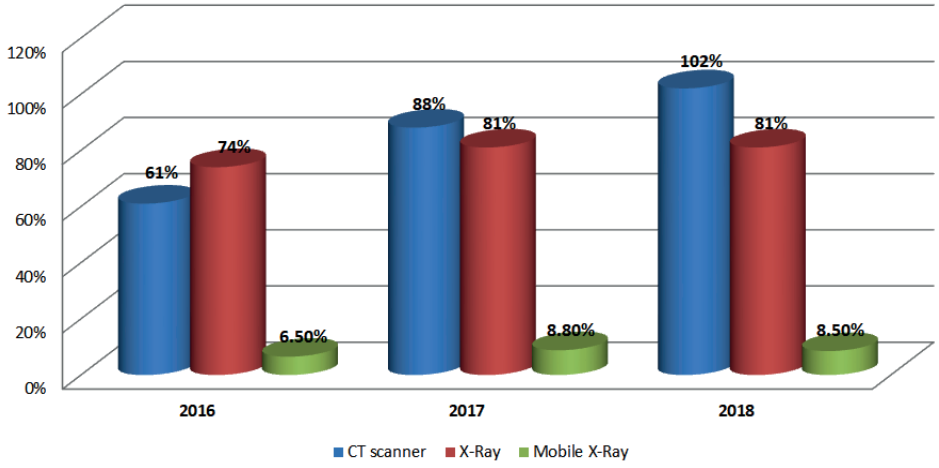


Figure 2. MedPAC – Medicare based utilization rate

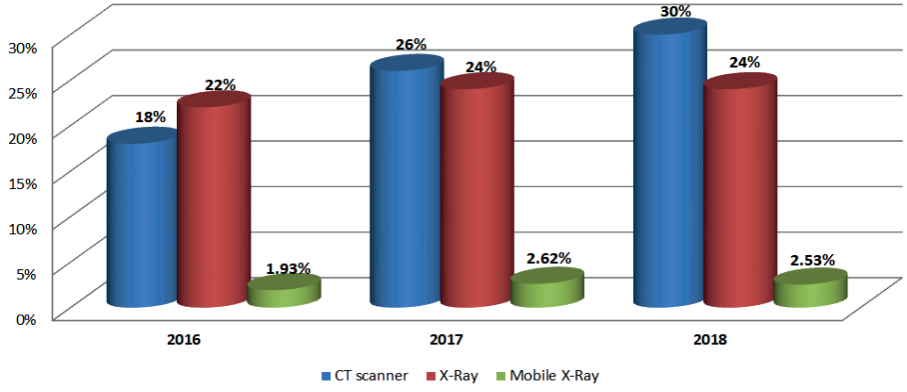


Figure 3. Modified Equation

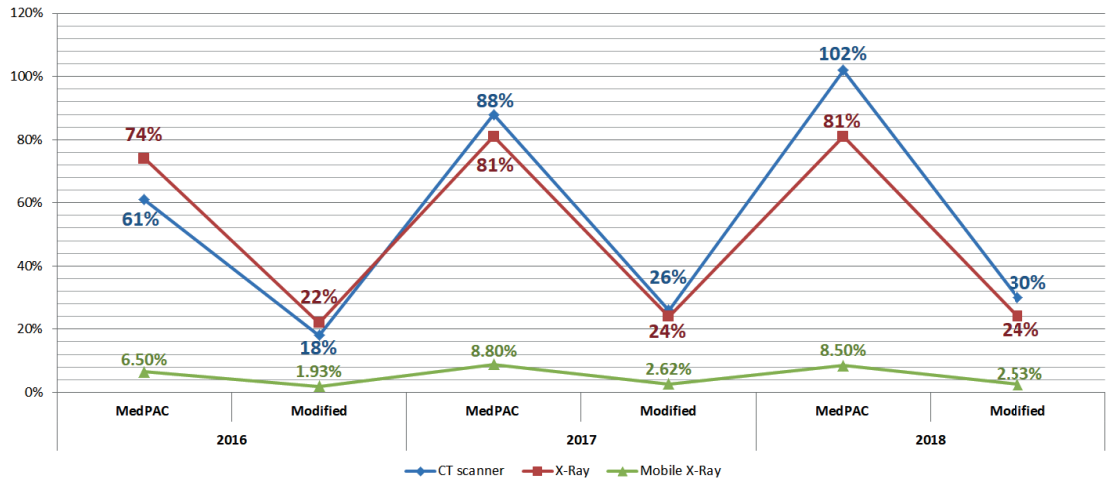


Figure 4. Comparison of the Results of the Two Equations

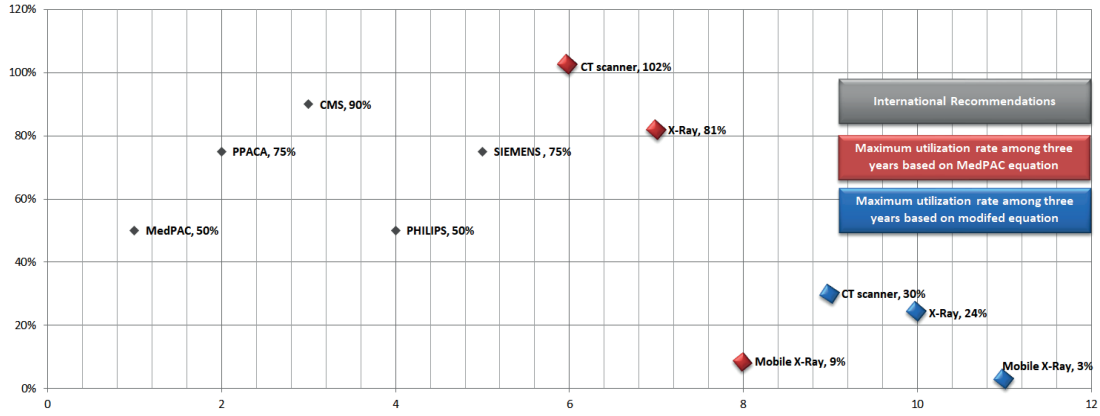


Figure 5. Study results in Comparison to the International Recommendations

Discussion

The study found out slight differences in utilization measured in the ED from 2016 to 2018 based on applying Canadian standard during the three years. CT scanner was not fully utilizing because the number of exams per year, in both government & private hospitals is less than 7,500 exams per year, and this number, according to the Canadian standard, is a low degree [25]. At the same time, for a government hospital, the X-Ray UR was very high because it exceeded the amount stipulated in the Canadian standard by 20,000 exams per year[25]. For mobile X-Ray, the UR is medium, and it is within range of the number specified in the Canadian standard [25]. Where, according to the data, the X-rays couldn't measure the exact use for X-ray (both fixed and mobile) in the private hospital because of the lack of information, were not distinguishing the source of the DMIE whether it is fixed or mobile. Unlike the collected data from the government hospital, the medical images specified from any device mentioned. So,

the study compared the data as an X-Ray device, so found UR in a medium based on Canadian standard [25].

The study applied the equation of (MedPAC) with government hospital data, but cannot apply it with private hospital data, due to the type of information is limited, for instance, not mentioning the downtime and patient spent time. Furthermore it (MedPAC) equation calculates available time as 3000 minutes, and it differs from the availability time of equipment in the emergency department. The high-cost medical devices are necessary to do scheduled maintenance for them, where the device is out of service, it is called unavailable time [29], which is not calculated in (MedPAC) equation. That is why this study shows great differences in the results compared with the radiology business management association (RBMA) final report[14]. Consequently, the unavailable time is an essential factor in calculating the real use of the medical device. Thus, working hours in the staff shifts so crucially too. That way, the higher results in this study of the CT scanner are 102%, which is illogical when it compares with the manufacturer recommended [17, 18]. While, (RBMA) report mentioned the UR based on (MedPAC) of CT scanner are 56% [14]. But, while the X-Ray results in this study are very high compares with manufacturer recommended [17, 18], also when it compares it with (RBMA), which indicates by 44% [14]. Whereas Mobile X-Ray, it was no downtime due to biomedical engineers who are replacing the device during the PPM or a breakdown. Furthermore, it is rarely needed compared to a fixed X-Ray device.

The CT scanner image is increase yearly, and this corresponds to the recently published research by Broder. Et, al at 2006 and 2007 [2, 4] that confirm that there is an increase in the need to use a CT scanner for medical services provided to patients in the emergency department while comparing the result of the UR in this research with the published use result, it is still within the recommended limit [17,18]. For this reason, the study clarifies the importance of the equation factor and how it affects the accuracy of the results. Working hours of ED, scheduled, and unscheduled equipment downtimes. This study realized that the UR of all equipment through the three years did not exceeded 30%. That is below the rate recommended by the manufacturer and international recommendations mentioned above. Therefore, it is a clear indicator that capital medical equipment in ED can be fully utilized to provide non-emergency medical services to patients. Fully utilize does not only mean using all the time without taking into consideration the safety of the device or under the optimal

use, which does not cause any damage to the equipment, healthcare institute, and its staff. To achieve the ability of utilization, the employees must utilize their capacities to achieve a goal of the facility is looking for it, and enable them to use their most grounded capabilities, giving them a sentiment of achievement.

Conclusion

On an average, the utilization of medical imaging equipment under study (the year 2016, 2017, and 2018) was less than 30% for Computed Tomography (CT) and Radiographic Systems (X-Ray), but for Radiographic Units, Mobile (Mobile X-Ray) rarely used less than 3%.

It became quite evident that the non-utilized equipment got influenced due to few patients coming to ED. The Canadian calculation is distinguished by speed and ease. Still, the disadvantage is that it is not accurate and does not give the correct results. It does not calculate the downtime of the device as well as times of service for periodic maintenance as it is equal to all imaging times, whether for one member of the body or the entire body.

Recommendation

To apply this modified approach for other equipment rather than radiological as it is of high beneficial impact on all medical equipment performances.

Funding

None

Conflicts of Interest

None

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