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# **Evaluation Of X-Ray Equipment Performance In Some Selected Hospitals Within Jos City, Plateau State, Nigeria**

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## **ABSTRACT**

This study evaluates the performance of X-ray equipment in five selected hospitals in Jos City, Plateau State, Nigeria, to assess their compliance with radiation safety and diagnostic quality standards. The research focuses on key performance parameters, including radiation leakage, kilovoltage peak (kVp) accuracy, and half-value layer (HVL). Using standardized tools such as the Unfors Mult-O-Meter 710L, GQ GMC-600 PLUS survey meter, and aluminum filters, measurements were conducted on five x-ray machines (labeled X1 to X5). The results reveal that X1, X2, and X3 exhibited radiation leakage of 0.22 mGy/hr, 0.24 mGy/hr, and 0.37 mGy/hr, respectively, all within the acceptable limit of 1 mGy/hr. However, X4 and X5 exceeded this threshold significantly, with leakage levels of 9.05 mR/hr and 9.91 mGy/hr indicating potential safety risks. All machines demonstrated kVp accuracy within the  $\pm 5\%$  tolerance limit, with deviations of 1.80% (X1), 2.46% (X2), 1.64% (X3), 1.55% (X4), and 1.48% (X5), ensuring reliable voltage output. HVL values were recorded as 2.88 mmAL (X1), 3.36 mmAL (X2), 2.98 mmAL (X3), 2.58 mmAL (X4), and 2.82 mmAL (X5), confirming adequate beam quality for diagnostic purposes. These findings highlight the need for regular quality assurance programs to address equipment deficiencies, reduce unnecessary radiation exposure, and enhance patient safety and diagnostic accuracy.

**Keywords:** radiation exposure, X-ray equipment, patient safety

## **1. INTRODUCTION**

Diagnostic radiology is responsible for almost 90% of the radiation exposure of the population from all sources other than natural background radiation [1]. With many powerful diagnostic procedures available today, X-rays are being used more and more frequently in diagnostic procedures and are now the standard and primary method of examination for the majority of illnesses and accidents [2]. This is due to the fact that they are low cost and easy to operate [3]. In diagnostic radiology, reduction of unnecessary radiation exposure and proper assessment of any diseases or fractures depend on the quality of the diagnostic images, with X-ray being a major contributor to both personnel's and patients' effective doses [3, 4]. It is necessary to keep radiation doses to patients and personnel as low as reasonably achievable (ALARA) because ionizing radiation, generated by X-rays, is associated with the risk of cancer and other stochastic radiation effects [4], even at low doses. Furthermore, better diagnostic images lead to more accurate diagnoses with minimum exposure by reducing rejected films. A fault in any single factor will affect the final image quality because these factors are largely interdependent; hence, there is the need for continuous quality assurance to minimize unwanted radiation exposure to patients and personnel and to provide quality images for proper and accurate diagnosis. Diagnostic radiology's quality assurance contributes significantly to the world's contemporary, high-quality healthcare system [5]. It guarantees

precise diagnostic data at the right dosages, lowering needless radiation risks to patients, employees, and the general public. Thus, it is crucial to regularly apply a well-established quality assurance procedure in all radiology departments to guarantee that the dosage from diagnostic x-ray exams is kept as low as is practically possible while preserving the best possible picture quality. Thus, it is necessary to shield people from the negative consequences of ionizing radiation.

**2. MATERIALS AND METHODS**

**2.1 Materials**

The materials used in this study are listed below.

Aluminum filters (six 1 mm thick aluminum sheets/filters), a radiation dosimeter (UNFORS Mult-O-Meter 710L), a radiation survey meter (GQ GMC-600 PLUS), a Zamo digital leaser tape and functional x-ray machines from five (5) radiological facilities in Jos Plateau State. The equipment specifications are presented in Table 1.

Table 1 Equipment Performance and Specifications

Characteristic	X1	X2	X3	X4	X5
<b>Equipment Name</b>	neusoft digital radiography system	general electric	Siemens	general electric	Ecoray
<b>model</b>	neuvision 460	ge rx7201	poly mobile plus	amx 4 plus	ultra 200 plus
<b>Serial number</b>	nv460ce-22090022	20 93478lh	(240)05605022	d2651p	eco-m20-1909013
<b>Company</b>	neusoft medical systems co., ltd. Shenyang Lianing China	general electric Bangkok thailand	siemens healthcare Germany	general electric system s. a. France	ecoray co. ltd. Korea
<b>Year of manufacture</b>	2022-10-20	September 2021	February 2021	2005	september 2019
<b>Year of installation</b>	2024	March 2022	October 2021	2019	July 2020
<b>Maximum kVp</b>	150	150	125	125	125
<b>Maximum mAs</b>	320	620	160	200	206

**2.2 METHODOLOGY**

**Measurement of radiation levels**

Leakage, if any, was measured using the GQ GMC-600PLUS radiation survey meter. The lowest tube current (50 mA) station was selected that was appropriate for the ionization survey meter's response time. The highest tube potential (80 kVp) allowable was selected, without exceeding the total heat capacity of the anode and the x-ray tube housing during the survey. With the Zamo digital tape positioned on the surface of an imaginary sphere of 1-meter radius with its center located at the focal spot, it was used to position the radiation detector. Exposures were made with close collimator blades or by blocking the

collimator port with at least 10 HVLs equivalent of lead. The radiation dose readings were taken in  $\mu\text{Sv/hr}$  directly from the display screen of the radiation detector.

#### **Peak Kilovoltage (kVp) test**

For the peak kilovoltage, a non-invasive tube voltage checks over a 100-kilovolt range was performed using an electronic multi-function radiation detector (Unfors Mult-O-Meter). For this investigation, a 100 cm source-detector distance (SDD) was used, representing the focus-to-film distance (FFD) of radiographic views. The x-ray tube was vertically positioned to the x-ray table and the beam was collimated over the detector, ensuring that the primary beam was centered on the detector. A collimated x-ray field size of 10 x 10 cm was used with the X-ray center axis aligned on the center point of the detector. The kVp of the x-ray machine was determined from the selected tube voltage of 100kVp and tube current of 14 mAs at the x-ray console. The output kVps were measured using the detector after every exposure over a selected kVp on the X-ray console. For each tube voltage selected, the machine was exposed at least five times, and the actual kVp for each exposure was measured by the detector, and the mean was taken. The accuracy of the kVp was then calculated using equation (1) below [6].

$$\text{Accuracy} = \frac{kVp(\text{measured}) - kVp(\text{set})}{kVp(\text{set})} \times 100\% \quad 1$$

Where kVp (measured) is the measured tube voltage and kVp (set) is the set tube voltage.

The result of the percentage deviation was then compared with the tolerance limit ( $\pm 5\%$ ) as recommended by the American Association of Physicists in Medicine [7].

#### **Half Value Layer (HVL) test**

To determine the HVL, the x-ray table was level and the central ray at  $90^\circ$  to the tabletop, then the Focus-Film-Distance (FFD) was set at 100 cm, after which the collimator light was switched on.

The radiation detector meter (Unfors-Mult-O-Meter 710L) was placed on the lead apron on the radiography couch along the central axis of the x-ray beam. A fixed kVp of 80 and 20m As selected from the control console, an x-ray exposure was performed five times for the selected exposure factors, and the meter reading was recorded. The first exposure was taken without any additional filter, while subsequent exposures were taken by first adding a 1 mm Al filter and then a 2 mm Al filter. In that manner, exposures were continued until the dose dropped to half the value of the very first exposure

### **3. RESULTS AND DISCUSSION**

The findings from this study are presented in this section; key performance parameters, including radiation leakage, kilovoltage peak (kVp) accuracy, and half-value layer (HVL), were determined. These parameters were measured using standardized tools and procedures, following protocols from the American Association of Physicists in Medicine [7] and the International Atomic Energy Agency [8].

#### **3.1 Leakage Radiation**

The leakage radiation test measures the amount of radiation that escapes from the X-ray tube through areas other than the designated window. According to the U.S. Environmental Protection Agency [9], the leakage radiation should not exceed 1.0 mSv/h at a given distance of 1 m from the X-ray tube. Table 2 presents the room background radiation and leakage radiation measurements at 1 meter from the studied X-ray machines.

Table 2 X-ray Room Background Radiation (BG) and Leakage Radiation

X-RAY MACHINE	BG		LEAKAGE RADIATION (mGy/hr)		
	( $\mu$ S/hr)	(mGy/hr)	CATHODE SIDE	ANODE SIDE	MEAN
X1	0.18	0.018	0.22	0.22	0.22
X2	0.24	0.024	0.25	0.23	0.24
X3	0.25	0.025	0.39	0.35	0.37
X4	0.32	0.032	8.10	10.00	9.05
X5	0.24	0.024	10.34	9.47	9.91
MAXIMUM	0.21	0.021	10.34	10.00	10.17
MINIMUM	0.25	0.025	0.22	0.22	0.22

### 3.2 kVp Measurements

Table 3 presents the kVp accuracy results of the measured kVp of the various X-ray machines.

kVp ACCURACY (%)									
X-ray Machine	Tube voltage selected (kVp)	Measured Tube voltages (kVp)					Mean	Standard Deviation (kVp)	kVp Accuracy (%)
		1	2	3	4	5			
X1	100	101.1	102.3	102.0	101.2	102.4	101.80	0.61	1.80
X2	100	102.2	103.1	102.6	102.0	102.4	102.46	0.42	2.46
X3	100	101.1	101.5	101.4	102.1	102.1	101.64	0.37	1.64
X4	100	980.3	98.50	97.74	99.14	98.84	98.45	0.57	1.55
X5	100	100.9	102.3	100.7	101.8	101.7	101.48	0.67	1.48

### 3.3 Half Value Layer (HVL) Test

Table 4 presents the Half Value Layer (HVL) measurements, the aluminum (mmAl) Thickness and the respective measured radiation dose using 100kVp and 20mAs at the studied facilities.

Table 4 Half Value Layer (HVL)

MmAl	kVp	mAs	DOSE ( $\mu$ Gy)				
			X1	X2	X3	X4	X5
0	100	20	313.00	245.30	407.60	602.50	322.83
1	100	20	256.70	200.80	333.90	478.30	246.42
2	100	20	199.10	158.30	249.50	356.80	201.35
3	100	20	150.90	133.50	202.80	261.40	152.82
4	100	20	111.50	103.10	159.60	197.90	133.21
5	100	20	96.90	85.40	131.20	130.30	112.20
DOSE	100	20	313.00	200.80	333.90	602.50	322.83
MAXIMUM							
DOSE	100	20	96.90	85.40	131.20	130.30	112.20
MINIMUM							
DOSE AT HVL	100	20	151.60	125.35	201.70	300.30	156.42

## 4 DISCUSSION

### 4.1 Leakage Radiation

Figure 1 illustrates the leakage radiation measured on the cathode side of the X-ray machines (X1–X5) at a distance of 1 meter, compared to the standard limit of 1 mR/hr as recommended by the International Commission on Radiological Protection (ICRP). The results show that X1, X2, and X3 recorded leakage radiation levels of 0.22, 0.25, and 0.39 mR/hr, respectively, all well below the standard limit. However, X4 and X5 exhibited significantly higher leakage radiation at 8.10 and 10.34 mR/hr, respectively, exceeding the acceptable threshold by substantial margins.

The low leakage radiation in X1, X2, and X3 suggests effective shielding and maintenance of the X-ray tube housing, aligning with findings by [10], who reported that well-maintained X-ray units typically exhibit leakage radiation within safe limits. These facilities likely adhere to regular quality control (QC) protocols, ensuring compliance with radiation safety standards. Conversely, the elevated leakage radiation in X4 and X5 indicates potential issues such as degraded tube housing or insufficient shielding materials. This is concerning, as excessive leakage radiation poses risks to radiographers, patients, and the public, as highlighted by Nkuba and Nyanda [11], who found that 47% of units in their study had radiation levels above safe limits at key locations. The high leakage in X4 and X5 may be attributed to their older manufacturing years (2005 and 2019, respectively) or inadequate maintenance schedules, as older equipment is more prone to wear, as noted by Ofotokun and Umuze [12]. These findings underscore the need for immediate corrective actions, such as replacing or repairing the tube housing and enhancing shielding, to ensure compliance with ICRP standards and protect occupational and public health.

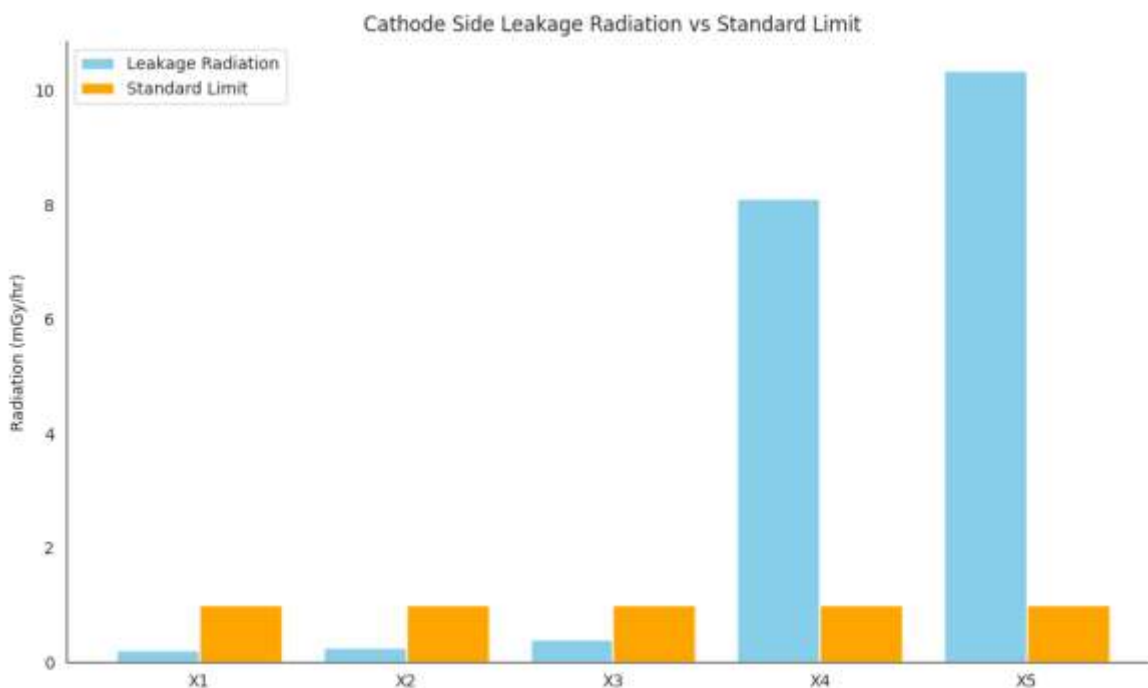


Figure 1: The Comparison of the Cathode Side Leakage Radiation at the Studied Facilities to the Standard Limit.

Figure 2 presents the anode-side leakage radiation for the X-ray machines, compared to the same ICRP standard limit of 1 mR/hr. Similar to the cathode side results, X1, X2, and X3 recorded low leakage radiation levels of 0.22, 0.23, and 0.35 mR/hr, respectively, indicating robust shielding on the anode side.

In contrast, X4 and X5 showed elevated levels at 10.00 and 9.47 mR/hr, respectively, exceeding the standard limit significantly.

The consistency of low leakage radiation in X1, X2, and X3 on both cathode and anode sides suggests symmetrical shielding integrity, which is critical for minimizing unintended radiation exposure. These results are comparable to Muhammad et al. (2018), who found that most X-ray units in their study complied with leakage radiation standards due to adequate shielding. However, the high leakage in X4 and X5 on the anode side mirrors the cathode-side findings, reinforcing concerns about equipment condition and maintenance. The slightly lower anode side leakage in X5 (9.47 mR/hr) compared to its cathode side (10.34 mR/hr) may indicate uneven wear or shielding deficiencies specific to the tube design. Effective shielding is essential for radiation safety [13], and the excessive leakage in X4 and X5 could increase the cumulative radiation dose to staff, particularly in high-workload settings. These findings highlight the urgency of conducting thorough QC assessments and implementing maintenance protocols to address shielding deficiencies in X4 and X5, ensuring alignment with ALARA (As Low As Reasonably Achievable) principles.

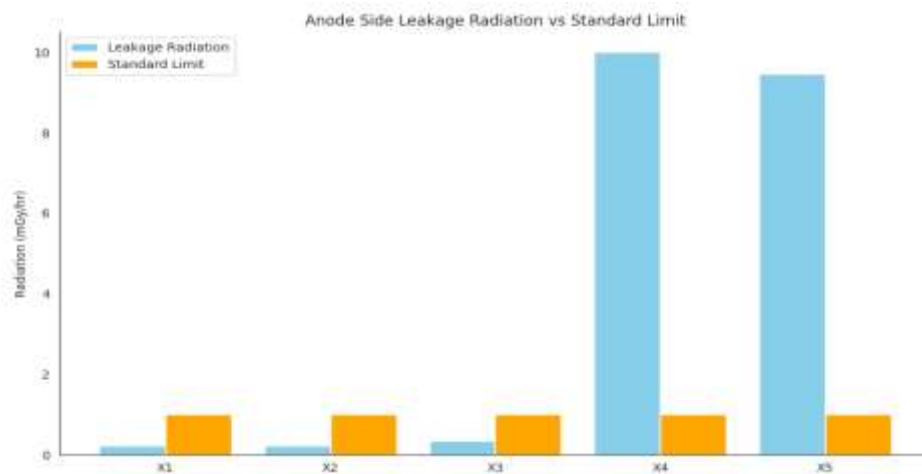


Figure 2. The Comparison of the Anode-Side Leakage Radiation at the Studied Facilities to the Standard Limit.

#### 4.2 kVp Measurements

Figure 3 illustrates the kilovoltage (kVp) accuracy of the X-ray machines (X1–X5) at a selected tube voltage of 100 kVp, compared to the tolerance limit of  $\pm 5\%$  as recommended by the American Association of Physicists in Medicine [7]. The kVp accuracy, calculated as the percentage deviation between the set and measured tube voltages, was 1.80% (X1), 2.46% (X2), 1.64% (X3), 1.55% (X4), and 1.48% (X5), all well within the acceptable tolerance limit.

The consistent kVp accuracy across all facilities indicates that the X-ray machines are reliably delivering the selected tube voltage, which is critical for producing diagnostic images with appropriate contrast and minimizing patient radiation exposure. These results align with another study [10], which reported kVp accuracies of 90.32–96.77% across various tube voltage settings, attributing compliance to regular quality control (QC) checks. The slightly higher deviation in X2 (2.46%) compared to other facilities may reflect minor calibration drift, but it remains well within the AAPM tolerance, suggesting negligible impact on image quality or dose. Notably, X4, despite its older manufacture (2005) and issues with leakage radiation (Figures 1 and 3), demonstrates excellent kVp accuracy (1.55%), indicating that its voltage control system is still functional. This finding contrasts with [14], who noted that older X-ray units often exhibit poorer kVp accuracy due to electronic wear. The high kVp accuracy across all facilities supports the reliability of exposure parameters, as emphasized by [6], and contribute to consistent image quality and patient safety. However, ongoing QC is essential to maintain this performance, as even small deviations in kVp can significantly affect radiation output and image contrast, as noted by [15].

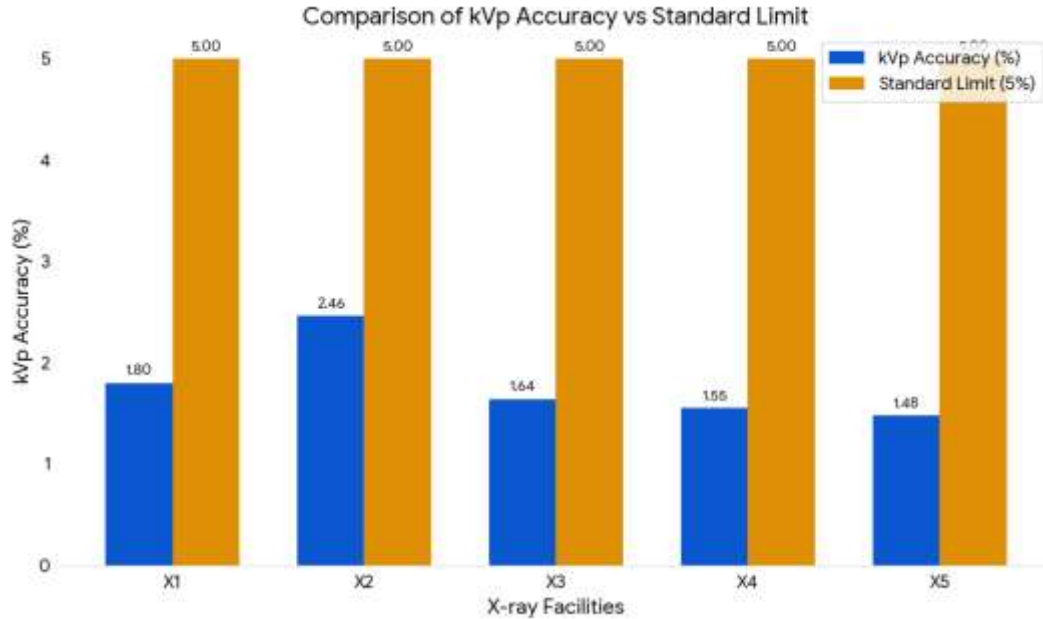


Figure 3: The Comparison of the Kilovoltage Accuracy at the Various Facilities to the Standard Limit.

#### 4.3 Half Value Layer (HVL) Test

Figure 4 depicts the Half Value Layer (HVL) determined for X1, showing an HVL of 2.88 mm Al at 100 kVp and 20 mAs. The HVL, which measures the aluminum thickness required to reduce the X-ray beam intensity by half, was calculated by plotting radiation dose against aluminum thickness and applying interpolation. This value exceeds the IAEA minimum of 2.3 mmAl for 80 kVp, indicating adequate beam filtration. The HVL of 2.88 mm Al suggests that X1's beam is effectively filtered, minimizing low-energy radiation that contributes to patient dose without improving image quality. Other findings [10] reported that 96.77% of X-ray machines in their study met HVL standards. X1's modern design (manufactured in 2022) likely incorporates advanced filtration materials, contributing to compliance with beam quality requirements. Regular monitoring remains essential, as filter degradation over time can reduce HVL and increase patient exposure.

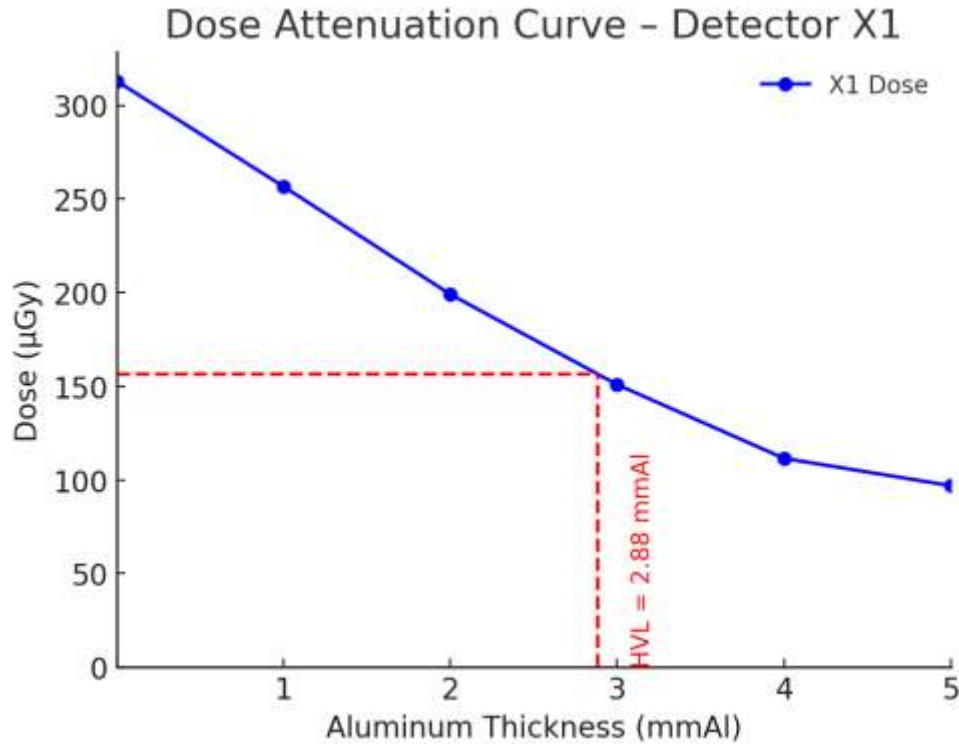


Figure 4. A graph showing the half-value layer of Al at the X1 X-ray facility using 100 kVp and 20 mAs.

Figure 5 shows the HVL for X2, determined as 3.36 mm Al at 100 kVp and 20 mAs, well above the IAEA minimum of 2.3 mm Al. This high HVL indicates excellent beam filtration, reducing unnecessary radiation exposure to patients. The HVL of 3.36 mmAl reflects X2's robust filtration system, likely due to its recent manufacture (2021) and installation (2022). This result is consistent with Ogbonna, M. I. I. et al. (2024) [16], who found that newer X-ray units exhibited superior beam quality due to effective filtration. The high HVL ensures that only higher-energy X-rays reach the patient, minimizing skin dose, as supported in another study (Delis, H., et al. 2017) [5]. Continued QC testing is recommended to sustain this performance, as environmental factors or equipment wear could affect filtration efficacy over time.

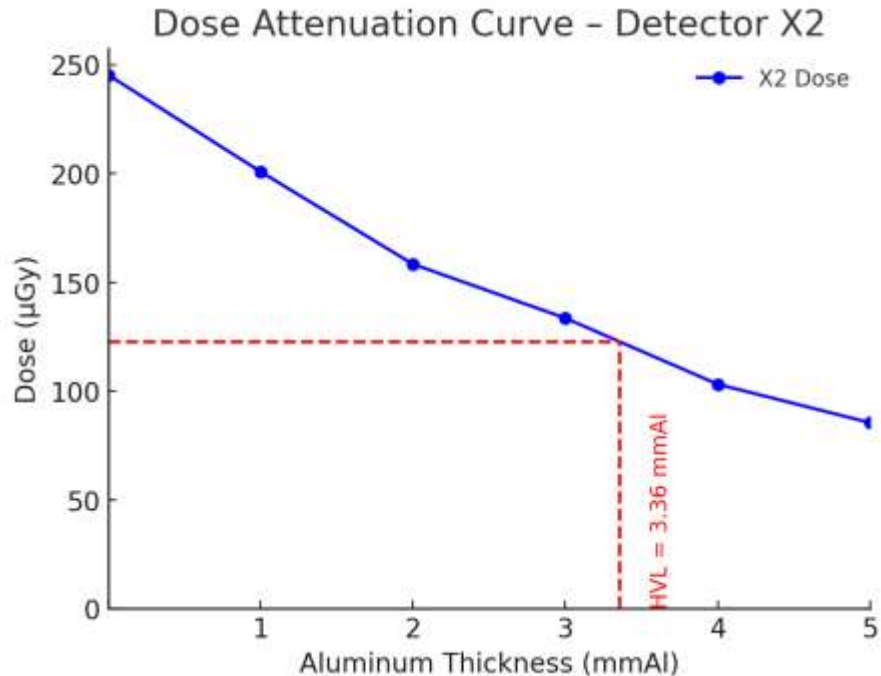


Figure 5. A graph showing the half-value layer of 3.36 mm Al at the X2 X-ray facility using 100 kVp and 20 mAs.

Figure 6 illustrates the HVL for X3, calculated as 2.98 mm Al at 100 kVp and 20 mAs, exceeding the IAEA minimum requirement of 2.3 mm Al. This indicates that X3's X-ray beam is adequately filtered, ensuring safe and effective diagnostic imaging. The HVL of 2.98 mmAl suggests that X3, manufactured in 2021, maintains a high standard of beam quality, comparable to X1 and X2. This aligns with a study by Nkuba, L. L., & Nyanda, P. B. [11], who reported that 98.2% of units in their study met HVL standards due to proper filtration. The slightly lower HVL compared to X2 may reflect minor variations in filter material or tube design but remains well within acceptable limits. Regular HVL assessments should be conducted to ensure ongoing compliance, particularly as X3 is relatively new and expected to maintain high performance.

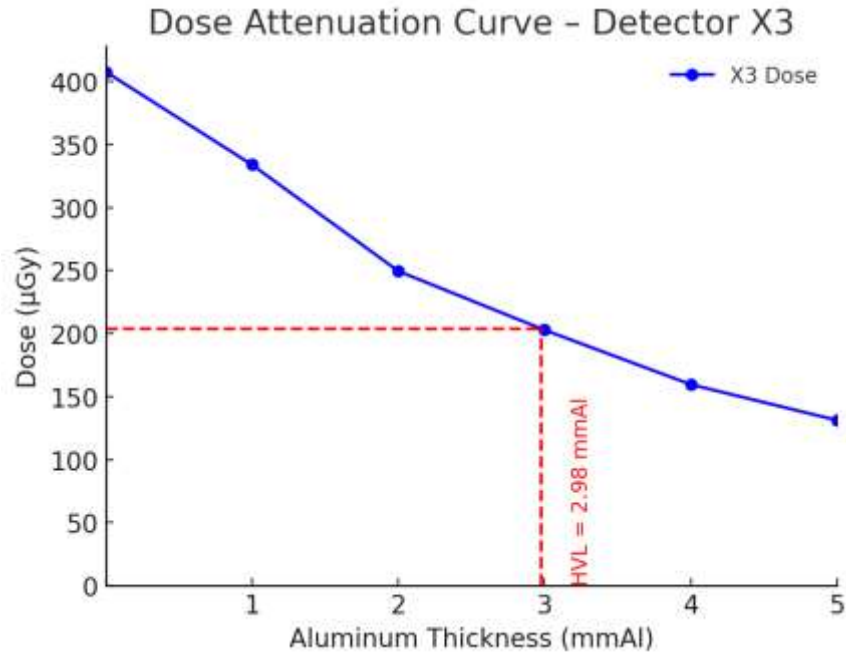


Figure 6. A graph showing the half-value layer of 2.98 mm Al at the X3 X-ray Facility using 100kVp and 20 mAs.

Figure 7 presents the HVL for X4, determined as 2.58 mm Al at 100 kVp and 20 mAs, slightly above the IAEA minimum of 2.3 mm Al. While compliant, this HVL is lower than that of X1, X2, and X3, indicating marginal beam filtration. The HVL of 2.58 mmAl suggests that X4's filtration is adequate but less robust than newer units, possibly due to its older manufacture (2005). This finding aligns with Njiki, C. D., et al. [17], which noted that older X-ray machines often exhibit lower HVL values due to filter wear or outdated designs. The marginal HVL could be linked to the high leakage radiation observed in earlier figures. This underscores the need for filter replacement or equipment upgrades to enhance beam quality, as recommended by Bem, T. T., et al. [18]. Enhanced QC protocols are essential to monitor and improve X4's performance, ensuring patient safety and diagnostic efficacy.

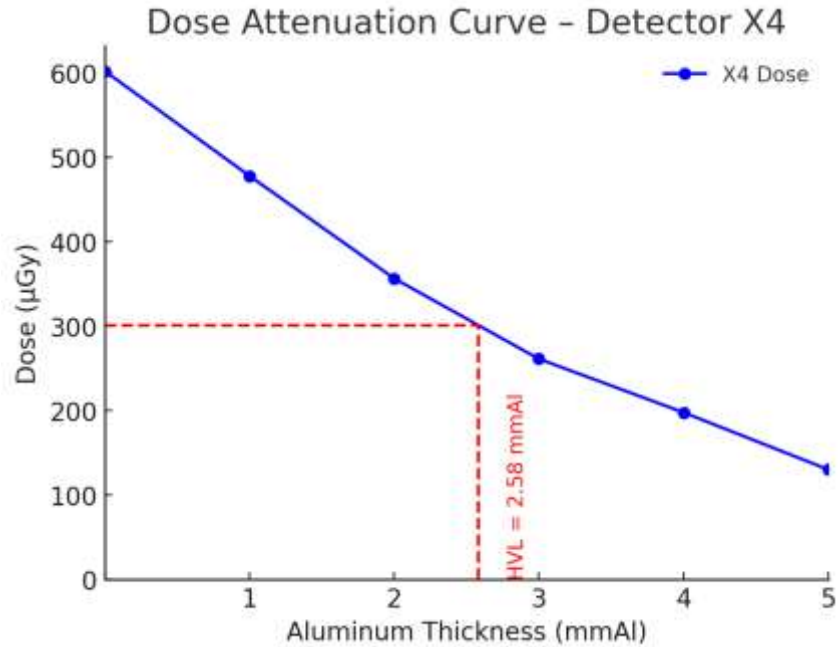


Figure 7: A graph showing the half-value layer of 2.58 mm Al at the X4 X-ray Facility using 100kVp and 20 mAs.

Figure 8 shows the HVL for X5, determined as 2.82 mm Al at 100 kVp and 20 mAs. This value exceeds the IAEA minimum of 2.3 mmAl, indicating that X5 has a robust filtration system. Compared to X4 (HVL of 2.58 mmAl), X5 demonstrates a higher HVL, suggesting better beam quality. This result supports the conclusion that X5's filtration system is effective in reducing low-energy, non-diagnostic radiation. Its performance is consistent with modern standards and contributes to safer imaging practices. Continued quality control is advised to maintain this level of beam filtration over time.

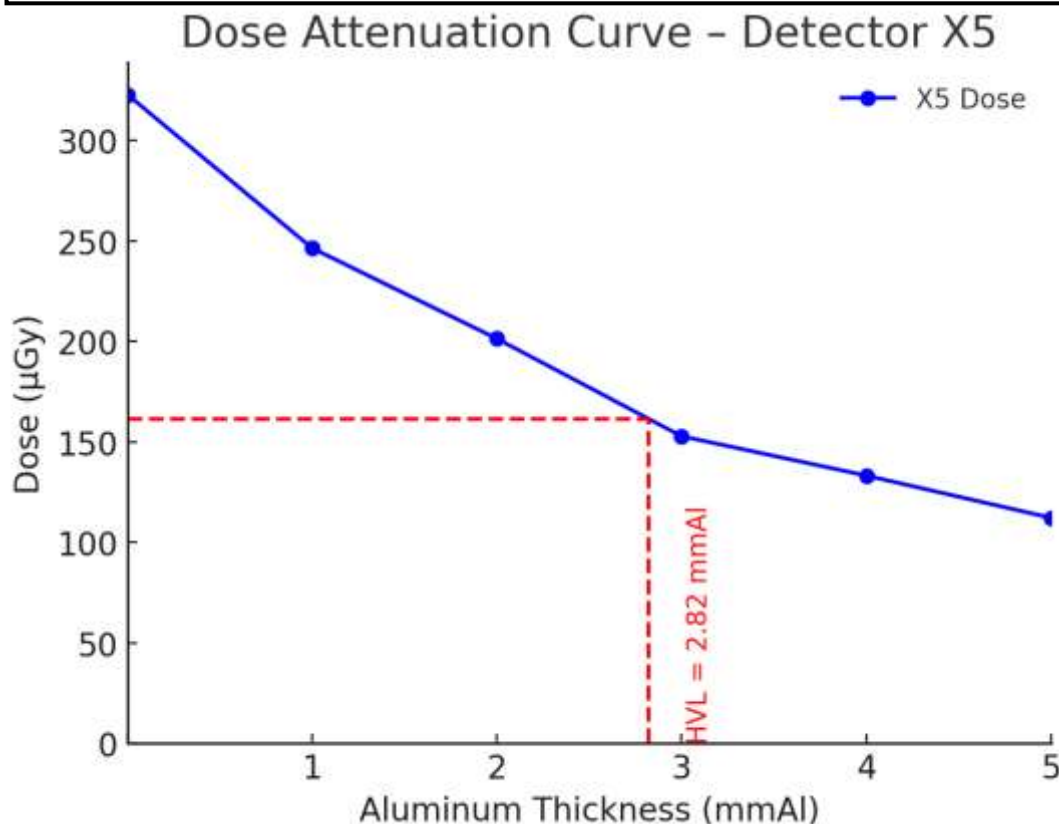


Figure 8. A graph showing the half-value layer of Al at the X5 X-ray Facility using 100kVp and 20 mAs.

### CONCLUSION

This study demonstrates that while most X-ray equipment in Jos hospitals performs within international safety and quality standards, significant deficiencies exist, particularly in radiation leakage from older systems (X4 and X5). The accurate kVp and HVL measurements indicate effective beam quality, safeguarding patient safety. However, excessive leakage in two facilities poses potential health risks to staff and visitors, emphasizing the need for enhanced maintenance and regulatory oversight. By providing a comprehensive performance evaluation, this research serves as a baseline for improving radiological safety and diagnostic accuracy in Jos, contributing to better healthcare delivery.

**AUTHOR CONTRIBUTION:** These authors contributed equally.

### REFERENCES

- [1] Frey, G. D., & Huda, W. (2007). Radiation Doses in Diagnostic Radiology: Methods and Measurements. *Medical Physics*, 34(4), 98–112.
- [2] Hussain, A., Ahmed, Z., Iqbal, M., & Khan, Y. (2022). Trends in X-Ray Diagnostic Procedures: A Global Perspective. *Journal of Radiological Protection*, 42(2), 145–152.
- [3] Muhammad, N. A., Nuraddeen, N. G., & Michael, A. O. (2018). Quality Control Analysis of Diagnostic Radiology Equipment In 44 Nigerian Army Reference Hospitals, Kaduna, Kaduna State, Nigeria. *FUDMA Journal of Sciences*. 2(4), 61-66
- [4] Patni N., Burela N., Pasricha R., Goyal J., Soni T.P., Kumar T.S. and Natarajan T. (2017). Assessment of threedimensional setup errors in image-guided pelvic radiotherapy for uterine and cervical cancer using kilovoltage cone-beam computed tomography and its effect on planning target volume margins. *Journal of Cancer Research and Therapeutics*, 13,131.

- [5] Delis, H., Christaki, K., Healy, B., Loreti, G., Poli, G. L., Meghzipene, A., & Manatrakul, N. (2017). Moving Beyond Quality Control in Diagnostic Radiology and the Role of the Clinically Qualified Medical Physicist. *Physica Medica*, 41, 104–108.
- [6] Godfrey, L. D., Adeyemo, D. J., & Sadiq, U. (2015). Radiological kVp Accuracy, Reproducibility, and Consistency Assessment of Some Hospitals in the Zaria Environs of Kaduna State, Nigeria. *Archives of Applied Science Research*, 7(1), 27–31.
- [7] American Association of Physicists in Medicine. (2002). Quality Control in Diagnostic Radiology (Report No. 74). *Medical Physics Publishing*.
- [8] International Atomic Energy Agency. (2018). *Radiation Protection and Safety in Medical Uses of Ionizing Radiation* (Safety Standards Series No. SSG-46). IAEA.
- [9] EPA (2000). Registration Requirements and Industry Best Practices for Ionizing Radiation Apparatuses Used in Diagnostic Imaging. Radiation Guidelines: Test protocols for parts 2 - 5 (Sydney: EPA, 2000).
- [10] Said, S., Goshu, B. S., Taju, E., & Tolawak, B. T. (2021). Quality Assurance and Control of Conventional X-Ray Machines at Different Hospitals and Clinics in Eastern Ethiopia. *Romanian Journal of Biophysics*, 31(2), 79-87.
- [11] Nkuba, L. L., & Nyanda, P. B. (2017). Compliance and Quality Control Monitoring of Diagnostic X-ray Facilities in Dar es Salaam, Tanzania. *Brazilian Journal of Radiation Sciences*, 5(2), 1–15.
- [12] Ofotokun, I., & Umuze, P. (2024). Dosimetric Evaluation of Diagnostic Radiology Practices in Delta State, Nigeria. *Innovative Journal of Science*, 7, 47-59.
- [13] Mori, M., Koshida, K., Ishigamori, O., & Matsubara, K. (2014). Effectiveness of X-Ray Protective Aprons: Experimental and Practical Evaluations. *Radiological Physics and Technology*, 7(1), 158–166.
- [14] Ateba, J. F. B., Simo, A., Ndontchueng, M. M., Sabouang, J. F., & Thierry, T. (2018). Quality Control Testing of Diagnostic X-ray Units in Cameroon. *Health Physics*, 114(5), 414–420.
- [15] Tiwari, A., Patel, S., Kumar, R., & Sharma, D. (2020). Quality Assurance in Diagnostic Radiology: Testing and Best Practices. *Journal of Applied Radiology and Imaging Science*, 9(3), 56–68.
- [16] Ogbonna, M. I. I., Austine, P. C., & Akpolile, F. D. (2024). X-ray Output Dose Assessment of Some X-ray Facilities in Jos Plateau State. *Ipho-Journal of Advance Research in Medical & Health Science*, 2(3), 20-25.
- [17] Njiki, C. D., Manyol, E. N., Yigbedeck, Y. H. E., & Ateba, J. F. B. (2018). Quality Control of Conventional Radiology Devices in Selected Hospitals of the Republic of Cameroon. *International Journal of Innovative Science, Engineering & Technology*, 5(3).
- [18] Bem, T. T., Shiada, M. S., & Akpa, T. C. (2018). Quality Control Parameter Assessment of X-Ray Machines Used in Hospitals within Makurdi. *Mind Sourcing Rad*, 3(12), 8.