

MEDICAL PHYSICS *International* Proceedings



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for Theoretical Physics



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College on Medical Physics 2026

DESCRIPTION:
The 2026 ICTP College on Medical Physics is designed to empower Medical Physics in LMICs by achieving Excellence in Medical Physics through Outreach, Workshops, Education, and Research, thus directly influencing the overall quality of healthcare.

MORE INFORMATION:
The College aims to provide a deep understanding of the fundamentals of medical imaging physics and their practical implementation in the management and operation of complex equipment. Another key aspect of the College is related to medical physics capacity building in developing countries.
The College presents the participants to transfer their knowledge to their colleagues. The participants receive a free certification of learning materials that enables them to engage with off activities in their own countries thus creating a wider global network to be the basis for sustainable growth of the profession in the developing regions.

TOPICS:
Fundamentals of Medical Imaging Physics
• Radiation sources
• Digital detectors
• Radiation dosimetry
• X-ray imaging - X-ray tubes, generators and imaging detectors
• Digital imaging - radiography, mammography, fluoroscopy, dental
• Computed Tomography (CT)
• Interventional radiology and fluoroscopy
• Single Photon emission Computed Tomography (SPECT)
• Medical Ultrasound - Ultrasonography (US)
• Magnetic Resonance Imaging (MRI)
• Hybrid Medical Imaging (PET/CT, PET/MR)
• Diagnostic imaging techniques, characteristics, quality, administration
• Radiation protection & safety

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P. Bragazzi
Piemonte Hospital Center, Italy
J. Chelomo
Emory University School of Medicine, USA
R. Padmanab
ICTP, Italy
R. Agazzi
Emory University School of Medicine, USA
R. Stamen
Medical University Plovdiv, Bulgaria
S. Talyakov
JUPITER, UK
S. Tjornehoj
Medical University of South Carolina, USA

24 August - 12 September 2026
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A limited number of grants are available to support the attendance of selected participants, with priority given to participants from developing countries. There is no registration fee.







MEDICAL PHYSICS INTERNATIONAL PROCEEDINGS

**THE JOURNAL OF
THE INTERNATIONAL ORGANIZATION FOR MEDICAL PHYSICS**



MEDICAL PHYSICS INTERNATIONAL

The Journal of the International Organization for Medical Physics

Aims and Coverage:

Medical Physics International (MPI) is the official IOMP journal. The MPI Proceedings provides a platform for medical physicists to share their experience, ideas and new information generated from conference abstracts/proceedings, and dissertation abstracts for recent graduates in medical physics or closely related fields. The e- journal is available free of charge to IOMP members.

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Radiation Dose Reduction in CT Simulation for Radiotherapy Treatment Planning Using Deep Learning-Based Image Enhancement

Ahmed E.Yousif¹

¹(Faculty of Medicine – Ain Shams University)

Computed Tomography (CT) simulation is a critical component of radiotherapy treatment planning, providing essential anatomical and electron density information required for accurate target delineation, organ-at-risk definition, and dose calculation. While CT simulation is indispensable for modern radiotherapy workflows, standard protocols are often adopted from diagnostic imaging settings and may result in excessive radiation exposure due to high tube current (mAs), unnecessarily long scan lengths, and uniform acquisition parameters that do not account for site-specific imaging requirements. This can be particularly relevant in patients who require multiple simulation scans throughout their treatment course or for adaptive radiotherapy planning. In this work, we propose a systematic, task-oriented approach to optimize CT simulation protocols with the aim of reducing radiation dose while strictly preserving image quality and dosimetric accuracy. A phantom-based study will be performed using a radiotherapy CT simulator, where standard clinical protocols will be compared with optimized protocols involving controlled adjustments of acquisition parameters such as tube current, pitch, and scan length tailored to the anatomical site being treated. Radiation dose metrics, including CTDIvol and Dose-Length Product (DLP), will be measured and analyzed to quantify the potential reduction in patient exposure. Image quality will be rigorously evaluated by assessing noise levels, Hounsfield Unit (HU) stability, and spatial resolution to ensure that electron density mapping for treatment planning remains reliable. The potential impact on radiotherapy treatment planning will also be assessed by examining the suitability of optimized scans for accurate contouring, target volume definition, and dose calculation within a treatment planning system. The proposed methodology is expected to demonstrate that site-specific, QA-guided optimization of CT simulation protocols can achieve substantial reductions in patient radiation dose without compromising the quality or accuracy of radiotherapy planning. This approach emphasizes a “fit-for-purpose” imaging philosophy, translating principles commonly used in radiotherapy planning into practical and reproducible strategies for routine clinical implementation, thereby supporting safer imaging practices, improved workflow efficiency, and enhanced quality assurance in CT simulation.

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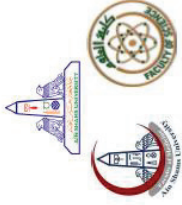
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Radiation Dose Reduction in CT Simulation for Radiotherapy Treatment Planning Using Deep Learning-Based Image Enhancement

Ahmed E. Yousif [1]

1: Radiation Oncology department, Faculty of Medicine, Ain-shams University



INTRODUCTION

Computed Tomography (CT) simulation is an essential component of radiotherapy treatment planning, providing accurate anatomical information for target delineation and dose calculation. However, CT imaging contributes additional radiation exposure to patients. Reducing acquisition dose through lower tube current (mAs) can substantially decrease patient exposure, but often results in increased image noise and reduced image quality. Recent advances in deep learning have enabled the development of image enhancement techniques capable of improving low-dose CT image quality while preserving important structural information.

AIM

To investigate the feasibility of reducing radiation dose during CT simulation for radiotherapy treatment planning and to evaluate the effectiveness of a Residual U-Net deep learning model for enhancing ultra-low-dose CT images.

METHOD

CT Phantom

A CT quality control phantom was scanned using one standard-dose protocol and six reduced-dose protocols.

Scan Parameters

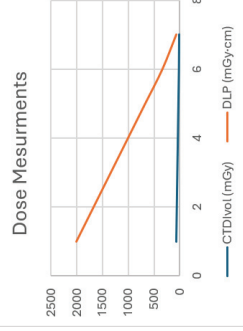
Parameter	Value
Tube Voltage	120 kVp
Rotation Time	0.75 s
Pitch	1.0
Slice Thickness	2 mm
Scan Length	20 cm

Protocol	kVp	mAs	Dose Reduction (%)
Standard	120	300	0
P1	120	250	17
P2	120	200	33
P3	120	150	50
P4	120	100	67
P5	120	50	83
P6	120	10	96.7

RESULTS

Dose Measurements

Protocol	CTDIvol (mGy)	DLP (mGy·cm)
Standard	72.0	2007.9
P1	60.2	1673.2
P2	48.2	1338.6
P3	36.1	1003.9
P4	24.1	669.3
P5	12.0	334.6
P6	6.3	66.2



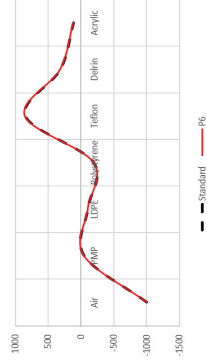
HU Accuracy Assessment (CTP404)

CT number accuracy was evaluated using material inserts:

Air
PMP
LDPE
Polystyrene
Acrylic
Delrin
Teflon

HU values remained stable across the investigated protocols, indicating preservation of quantitative CT information despite dose reduction.

HU Accuracy Assessment (CTP404)

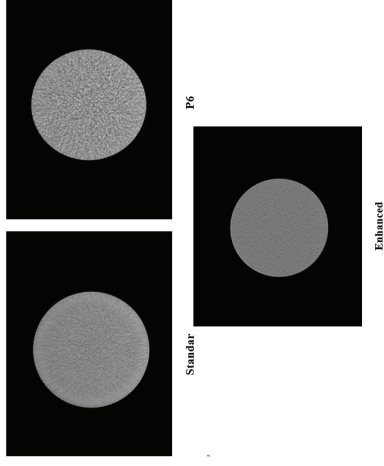


Deep Learning Performance

Visual comparison demonstrated:

- Reduced image noise in low-dose CT images.
- Preservation of phantom boundaries and internal structures.
- Elimination of checkerboard artifacts through bicubic up sampling.
- Improved similarity to the standard-dose reference image.

Deep Learning-Based Image Enhancement



CONCLUSIONS

- CT simulation dose can be substantially reduced while maintaining clinically useful image quality.
- A reduction from **300 mAs to 10 mAs (96.7% reduction)** was achieved.
- HU consistency was preserved across acquisition protocols.
- Deep learning-based enhancement improved low-dose CT image appearance and reduced image noise.
- Residual U-Net demonstrates potential as a tool for CT dose optimization in radiotherapy treatment planning.

CONTACT INFORMATION

Email:- ahmedyousif2991994@gmail.com,
Phone number:- +02 01142034958

ESTABLISHMENT OF PRIMARILY LOCAL DIAGNOSTIC LEVELS FOR ADULT CT EXAMINATIONS

Ibtihaj Alhoderi¹, Aram Genaw¹, Zyad Alhershi¹.

1Department of Radiation Medical Physics, Tripoli University Hospital, Tripoli –Libya

1. INTRODUCTION: Computed tomography (CT) is a major contributor to patient radiation exposure in diagnostic imaging [1, 2]. Optimization in radiation protection requires that patient doses be kept as low as reasonably achievable while preserving diagnostic image quality [1, 2]. Diagnostic Reference Levels (DRLs) are internationally recommended investigation levels to identify unusually high radiation doses and guide protocol optimization [1, 2]. Libya currently lacks established DRLs. This study aims to establish preliminary local DRLs for adult CT Brain, Chest, and Abdomen examinations in Tripoli University Hospital (TUH) as a foundation for a national dose management framework [1, 2].

2. METHODS: A retrospective audit is conducted for adult patients undergoing routine CT Brain, Chest, and Abdomen examinations in Tripoli University Hospital. Computer tomography dose index (CTDI_{vol} (mGy)) and Dose-Length Product (DLP (mGy·cm)) were extracted from scanner-generated dose reports[3,4,5]. Internal validation was performed by verifying the mathematical relationship $DLP = CTDI_{vol} \times \text{scan length}$, to ensure consistency of recorded dose metrics [5,6].

The estimated effective dose (ED (mSv)) was calculated from DLP using region-specific adult DLP-to-effective-dose conversion coefficients (k-factors), according to: $ED \text{ (mSv)} = DLP \text{ (mGy} \cdot \text{cm)} \times k \text{ [mSv/(mGy} \cdot \text{cm)]} \dots 1$

Where: ED = Estimated Effective Dose (mSv), DLP = Dose Length Product (mGy·cm), k = DLP-to-effective-dose conversion coefficient (mSv/(mGy·cm)) [7].

The 75th percentile of dose distribution was proposed as the local DRL for brain[1, 2].

3. RESULT: A total of 35 CT examinations were retrospectively analyzed. All examinations were performed at 120 kVp, with a mean tube current of 185.2 ± 10.5 mAs. CT examinations were classified according to the anatomical region examined. For each examination, CTDI_{vol} (mGy) and DLP (mGy·cm) were recorded and analyzed by anatomical region. The overall mean CTDI_{vol} was 20.85 ± 1.23 mGy, while the mean DLP was 1164.5 ± 441.5 mGy·cm. CTDI_{vol} showed relatively limited variability compared with DLP, suggesting that differences in scan length and anatomical coverage contributed substantially to the observed variation in DLP.

The estimated ED ranged from 2.68 mSv for brain examinations to 25.52 mSv for abdomen–pelvis examinations. Chest examinations showed an estimated ED of 22.73 mSv, while chest–abdomen–pelvis (CAP) examinations showed an estimated ED of 21.91 mSv. Effective dose was not estimated for the Chest–Abdomen and Brain + Chest + Abdomen + Pelvis examination groups, as no directly applicable published conversion coefficients were identified for these specific scan ranges.

The 75th percentile (P75) of the DLP for adult CT Brain examinations was 1156.5 mGy·cm. This value is proposed as the preliminary local Diagnostic Reference Level (DRL) for brain CT in Tripoli University Hospital, providing a benchmark for identifying unusually high patient doses and supporting future protocol optimization and establishment of national CT DRLs in Libya.

4. CONCLUSION: Establishing institutional Diagnostic Reference Levels (DRLs) for CT brain, chest, and abdomen examinations provides a structured baseline for patient dose assessment at Tripoli University Hospital. Although data collection is ongoing, these institutional DRLs provide a foundation for systematic dose monitoring and optimization, strengthen radiation protection practices, and represent an important step toward the future development of a national DRL framework aligned with international standards.

4. REFERENCES

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- [2] International Atomic Energy Agency, Radiation Protection and Safety in Medical Uses of Ionizing Radiation, GSR Part 3, 2014.
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ESTABLISHMENT OF PRIMARILY LOCAL DIAGNOSTIC LEVELS FOR ADULT CT EXAMINATIONS

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¹ Department of Radiation Medical Physics, Tripoli University Hospital, Tripoli –Libya

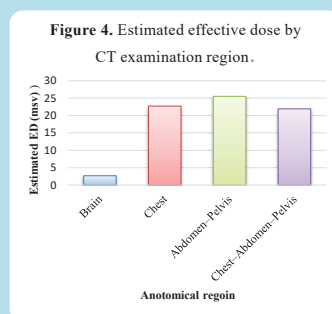
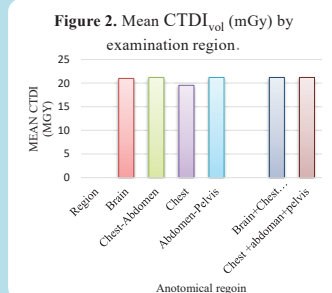
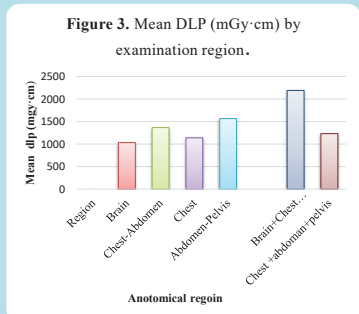
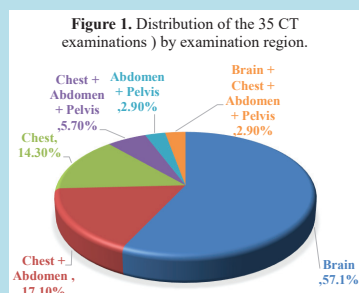
01 INTRODUCTION

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03 RESULTS

A total of 35 CT examinations were retrospectively analyzed. All examinations were performed at 120 kVp, with a mean tube current of 185.2 ± 10.5 mAs. CT examinations were classified according to the anatomical region examined. For each examination, $CTDI_{vol}$ (mGy) and DLP (mGy·cm) were recorded and analyzed by anatomical region.

The distribution of examinations by anatomical region is shown in Figure 1. The mean $CTDI_{vol}$ and mean DLP for each examination region are presented in Figures 2 and 3, respectively.



04 CONCLUSION

Establishing institutional Diagnostic Reference Levels (DRLs) for CT brain, chest, and abdomen examinations provides a structured baseline for patient dose assessment at Tripoli University Hospital. Although data collection is ongoing, these institutional DRLs provide a foundation for systematic dose monitoring and optimization, strengthen radiation protection practices, and represent an important step toward the future development of a national DRL framework aligned with international standards.

02 METHODS

A retrospective audit is conducted for adult patients undergoing routine CT Brain, Chest, and Abdomen examinations in Tripoli University Hospital. Computer tomography dose index ($CTDI_{vol}$ (mGy)) and Dose-Length Product (DLP (mGy·cm)) were extracted from scanner-generated dose reports [3,4,5].

Internal validation was performed by verifying the mathematical relationship $DLP = CTDI_{vol} \times \text{scan length}$, to ensure consistency of recorded dose metrics [5,6].

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Where: ED = Estimated Effective Dose (mSv), DLP = Dose Length Product (mGy·cm), k = DLP-to-effective-dose conversion coefficient (mSv/(mGy·cm)) [7].

The 75th percentile of dose distribution was proposed as the local DRL (Tripoli university hospital) for brain, following international methodology [1, 2].

The overall mean $CTDI_{vol}$ was 20.85 ± 1.23 mGy, while the mean DLP was 1164.5 ± 441.5 mGy·cm. $CTDI_{vol}$ showed relatively limited variability compared with DLP, suggesting that differences in scan length and anatomical coverage contributed substantially to the observed variation in DLP.

The ED was calculated from the mean DLP using published ICRP 103-based, 120-kVp DLP-to-effective-dose conversion coefficients [7]. The calculated ED values are presented in Table 1 and illustrated in Figure 4.

Table 1. Mean DLP, applied conversion factors, and estimated effective dose by examination region.

Examination Region	Mean DLP (mGy·cm)	k-factor (mSv/mGy·cm)	Estimated ED (mSv)
Brain	1032.505	0.00260	2.68
Chest	1136.980	0.0199	22.73
Abdomen-Pelvis	1565.500	0.0163	25.52
Chest-Abdomen-Pelvis	1230.950	0.0178	21.91

The estimated ED ranged from 2.68 mSv for brain examinations to 25.52 mSv for abdomen-pelvis examinations. Chest examinations showed an estimated ED of 22.73 mSv, while chest–abdomen–pelvis (CAP) examinations showed an estimated ED of 21.91 mSv. Effective dose was not estimated for the Chest–Abdomen and Brain + Chest + Abdomen + Pelvis examination groups, as no directly applicable published conversion coefficients were identified for these specific scan ranges.

The 75th percentile (P75) of the DLP for adult CT Brain examinations was 1156.5 mGy·cm. This value is proposed as the preliminary local Diagnostic Reference Level (DRL) for brain CT in Tripoli University Hospital, providing a benchmark for identifying unusually high patient doses and supporting future protocol optimization and establishment of national CT DRLs in Libya.

05 REFERENCES

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Impact of Gender and BMI on PET SUV Overestimation: A Liver and Blood Pool Analysis

Sanaa Al Rashdi, Subhash Kheruka, Naema Al Maymani,

Noura Al Maknhiari, Huda Al Saidi, Tasnim Al Raii,

Anas Al Balushi, Khulood Al Riyami, Rashid Al Sukaiti

*Department of Radiology and Nuclear Medicine,
Sultan Qaboos Comprehensive Cancer Care and Research Centre,
University Medical City, Oman*

Aims

This study investigates the impact of gender and body mass index (BMI) on the overestimation of Standardized Uptake Values (SUVs) compared to lean body mass-adjusted SUVs (SULs) in liver and blood pool PET/CT scans, aiming to identify quantification biases and their implications for clinical interpretation.

Materials & Methods

A retrospective analysis was conducted on 182 adult patients (93 females, 89 males) who underwent F-18 FDG PET/CT imaging. Patients were stratified into BMI categories: normal weight (18.5–24.9), overweight (25–29.9), and obese (≥ 30). SUVmax and SUVmean for the liver and blood pool were compared with SUL values, calculated using the formula:

$$\text{SUL} = \text{SUV} \times \text{Lean Body Mass (LBM)} / \text{Total Body Weight}$$

Percentage differences between SUV and SUL were analyzed across gender and BMI groups. Statistical significance was assessed using a two-sample t-test.

Results

SUV overestimation increased significantly with BMI ($p < 0.0001$) in both genders. Females exhibited greater discrepancies, with liver SUVmax exceeding SUL by 28.1% in normal-weight individuals and 43.4% in obese individuals, compared to 22.4% and 37.4% in males, respectively. Blood pool SUV-SUL differences followed a similar trend, with overweight and obese females showing the highest discrepancies.

Conclusion

Females, particularly those with higher BMI, demonstrate greater SUV overestimation compared to males. These findings emphasize the importance of incorporating body composition adjustments, such as lean body mass, for accurate PET quantification. Standard SUV measurements may lead to misinterpretations of metabolic activity, especially in overweight and obese individuals, underscoring the need for refined approaches in PET image analysis.

Keywords: PET/CT, SUV, SUL, Lean Body Mass, BMI, Gender Differences, Quantification Bias, Obesity



SULTAN QABOOS
COMPREHENSIVE
CANCER CENTRE
Sultanate Of Oman
University Medical City



IMPACT OF GENDER AND BMI ON PET SUV OVERESTIMATION: A LIVER AND BLOOD POOL ANALYSIS

Sanaa Al Rashdi, Subhash Kheruka, Naema Al Maymani, Noura Al Maknhiari,
Huda Al Saidi, Tasnim Al Raii, Anas Al Balushi, Khulood Al Riyami, Rashid Al Sukaiti
*Radiology and Nuclear Medicine Department, Sultan Qaboos Comprehensive Cancer Care and Research Centre,
Sultanate of Oman University Medical City, Muscat, Oman*

AIM

To evaluate the effect of gender and BMI on SUV overestimation compared with lean body mass-adjusted SUV (SUL) in liver and blood pool PET/CT measurements, and assess its impact on quantitative PET interpretation.



MATERIALS & METHODS

Study Population

- Retrospective analysis
- 182 adult patients
- 93 females, 89 males

BMI Categories (WHO)

- Normal weight: 18.5 – 24.9 kg/m²
- Overweight: 25.0 – 29.9 kg/m²
- Obese: ≥30.0 kg/m²

PET Parameters

- Liver SUV_{max}, SUV_{mean}
- Blood pool SUV_{max}, SUV_{mean}

Lean Body Mass Adjustment

$$SUL = SUV \times \frac{LBM}{Total\ Body\ Weight}$$

LBM calculated using the scanner's standard James equation.

Statistical Analysis

- Percentage difference between SUV and SUL calculated
- Two-sample t-test used for comparisons between groups
- $p < 0.05$ considered statistically significant



10



ABBREVIATIONS

PET/CT: Positron Emission Tomography/Computed Tomography
SUV: Standardized Uptake Value SUL: Lean Body Mass-Adjusted SUV
LBM: Lean Body Mass BMI: Body Mass Index %FDG: ¹⁸F-fluorodeoxyglucose



CONTACT

Sanaa Al Rashdi, BSc, Medical Physicist
s.alrashdi@cccrc.gov.om



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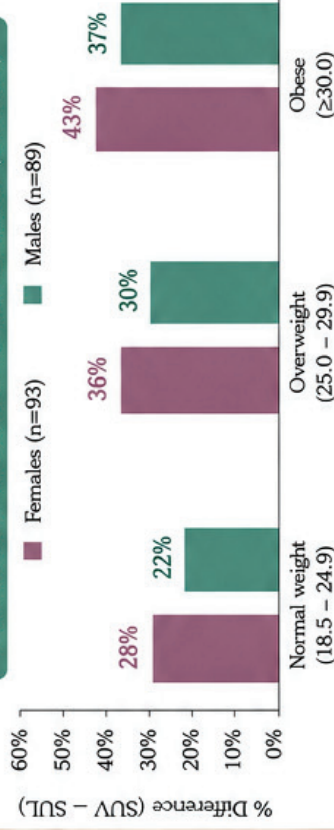
We thank the Nuclear Medicine and Medical Physics team at SQCCRC for their support.

RESULTS



SUV overestimation relative to SUL increased significantly with increasing BMI in both sexes ($p < 0.00001$), with consistently greater overestimation observed in females across all BMI categories.

LIVER SUV_{max}: % OVERESTIMATION (SUV vs SUL)



Females vs Males
(Liver SUV_{max})

- Normal weight: 28% vs 22%
- Overweight: 36% vs 30%
- Obese: 43% vs 37%

BLOOD POOL SUV_{mean}: % OVERESTIMATION (SUV vs SUL)



Females vs Males
(Blood Pool SUV_{mean})

- Normal weight: 24% vs 18%
- Overweight: 31% vs 24%
- Obese: 39% vs 32%



KEY FINDING: Female patients demonstrated consistently greater SUV overestimation than males, with the largest differences observed in the obese group across both liver and blood pool measurements.

CONCLUSION



SUV overestimation is significantly influenced by both gender and BMI, with the greatest effect observed in obese female patients, highlighting the need for body composition-adjusted PET quantification.



These findings highlight the limitations of conventional SUV measurements and support the use of lean body mass-adjusted SUL for more accurate and standardized quantitative PET assessment.



Incorporating body composition correction may reduce quantification bias and improve the consistency of clinical interpretation, particularly in overweight and obese patients.

KEY TAKEAWAY



Routine SUV measurements may overestimate metabolic activity, particularly in overweight and obese female patients. Incorporating lean body mass-adjusted SUL can improve the accuracy and consistency of PET quantification.



We thank the Nuclear Medicine and Medical Physics team at SQCCRC for their support.

A Medical Physics–Driven Framework for Multimodal AI in Breast Imaging

Jawaher AL-Tuweity^{*}, João Paulo Papa

*Computing Department, Faculty of Sciences-University of São Paulo State UNESP, Bauru-
Brazil*

**Email: Jawaher.altuweity@unesp.br*

Abstract

Breast cancer imaging increasingly relies on complementary modalities, including mammography, digital breast tomosynthesis (DBT), ultrasound (US), magnetic resonance imaging (MRI), and positron emission tomography (PET). Each modality provides distinct anatomical, structural, functional, or metabolic information, but also presents modality-specific limitations related to image quality, spatial resolution, artifacts, acquisition protocols, and, for ionizing modalities, radiation exposure. Artificial intelligence (AI), particularly deep learning, has demonstrated substantial potential for breast lesion detection, segmentation, classification, and treatment-response prediction; however, many existing approaches focus on individual modalities and may not fully exploit complementary information across imaging sources.

This work proposes a medical physics–driven framework for multimodal AI in breast imaging, integrating image-quality assessment, radiation-dose considerations, multimodal data harmonization, deep representation learning, fusion strategies, explainable AI (XAI), and clinical decision support. The proposed workflow incorporates modality-specific preprocessing followed by feature extraction using convolutional neural networks, vision transformers, Swin Transformers, or U-Net-based architectures. Multimodal information is subsequently integrated through data-level, feature-level, decision-level, or hybrid fusion strategies. XAI approaches, including Grad-CAM and feature-attribution methods, are incorporated to improve the interpretability of AI predictions.

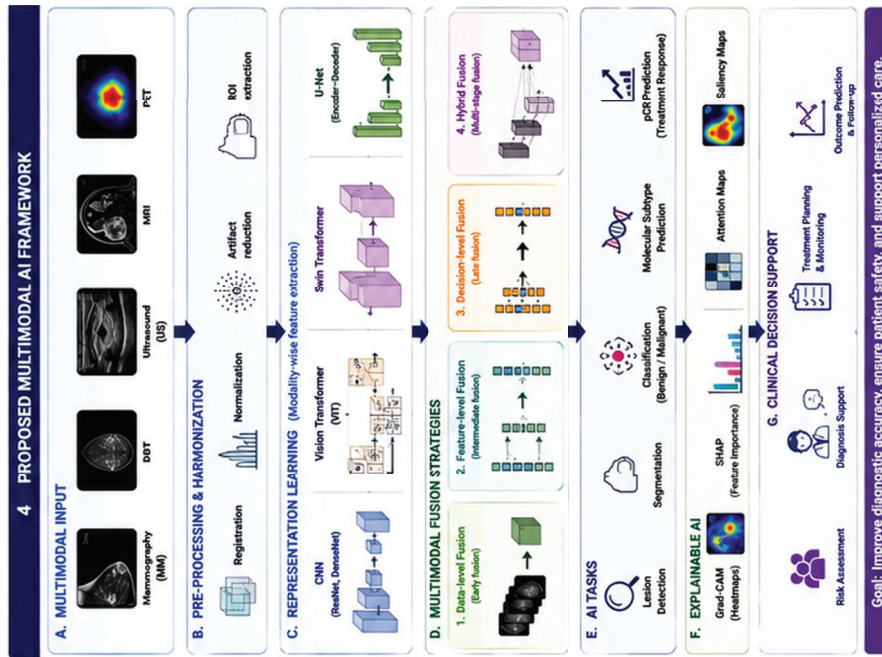
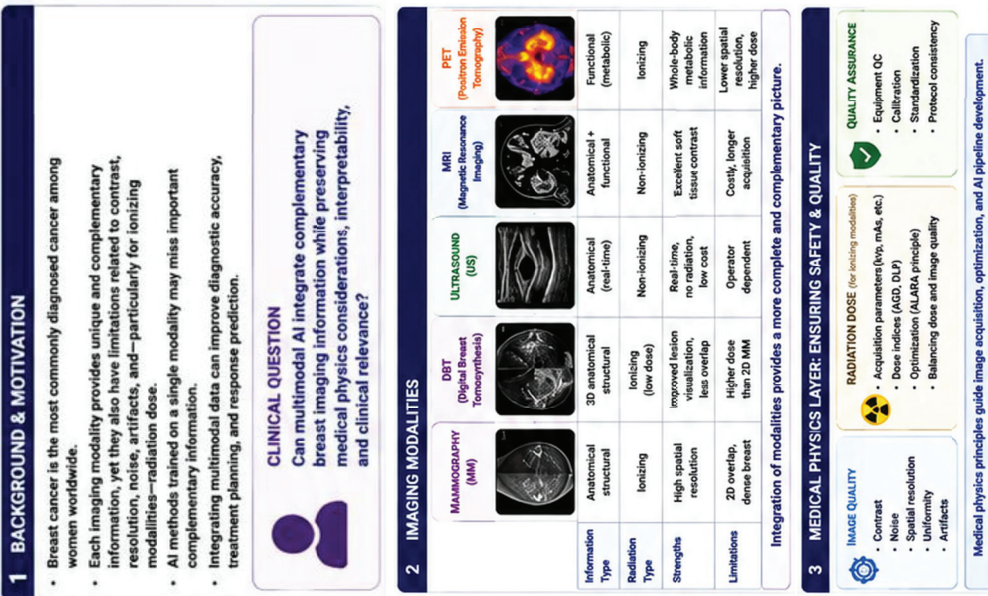
The current work focuses on framework development, literature-based taxonomy, and computational implementation; quantitative experimental validation is ongoing. Future studies will evaluate the framework using breast imaging datasets for lesion detection, segmentation, classification, molecular characterization, and treatment-response prediction. By explicitly integrating medical physics principles with multimodal AI, the proposed framework aims to support the development of robust, interpretable, reproducible, and clinically relevant AI-assisted breast imaging systems.

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Computing Department, Faculty of Sciences ,University of São Paulo State UNESP

Jawaher AL-TUWEITY*; João Paulo Papa

*Email: Jawaher.altuweity@unesp.br



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Let's connect!



OPTIMIZATION AND ASSESSMENT OF PATIENT RADIATION DOSE IN DIGITAL BREAST TOMOSYNTHESIS: ANALYSIS OF INFLUENCING FACTORS AND DOSE OPTIMIZATION STRATEGIES

Assaoui Fatna^{1*}, and Omor Youssef²

¹*Section of Radiology, Higher Institute of Nursing Professions and Health Techniques,
University Mohammed V, Rabat-Morocco*

²*Department of Radiology, National Institute of Oncology, Rabat-Morocco*

***E-mail: Assaoui2003@yahoo.fr**

Abstract:

Digital Breast Tomosynthesis (DBT), implemented on full-field digital mammography (FFDM) systems, has improved breast cancer detection through enhanced lesion conspicuity and reduced tissue overlap. However, the acquisition of multiple low-dose projections raises concerns regarding cumulative radiation exposure, particularly in screening programs. In Morocco, limited published data are available on patient dose levels in DBT, highlighting the need for local dose assessment and optimization.

This study aims to evaluate patient radiation dose during DBT examinations performed on a FUJIFILM full-field digital mammography system and to identify the main factors influencing dose variability. A retrospective analysis was conducted on 100 patients who underwent DBT examinations. Dose-related parameters, including Average Glandular Dose (AGD), tube voltage (kVp), tube current–time product (mAs), compressed breast thickness, and target/filter combinations, were extracted from DICOM headers via the PACS system.

Statistical analysis was performed to assess the correlation between AGD and technical as well as anatomical parameters. Breast thickness and exposure settings were identified as primary determinants of dose variation. Based on these findings, optimization strategies were proposed, focusing on protocol standardization, appropriate use of automatic exposure control (AEC), and reinforcement of quality assurance practices to ensure adherence to the ALARA principle without compromising diagnostic image quality.

The outcomes of this study provide baseline data for establishing local Diagnostic Reference Levels (DRLs) for DBT in Morocco and contribute to strengthening radiation protection practices in breast imaging. This work aligns with IAEA safety standards and supports the development of medical physics expertise in dose optimization and quality assurance in emerging imaging technologies.

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¹Section of Radiology, Higher Institute of Nursing Professions and Health Techniques, University Med V, Rabat-Morocco
²Department of Radiology, National Institute of Oncology, Ibn Sina University Hospital Center, Rabat-Morocco

^{1*}ASSAOUI Fatna, ²OMOR Youssef

*E-mail: Assaoui2003@yahoo.fr



OBJECTIF: This study aims to evaluate patient radiation dose during Digital Breast Tomosynthesis examinations performed on a FUJIFILM full-field digital mammography system and to identify the main factors influencing dose variability.

Digital Breast Tomosynthesis (DBT), implemented on full-field digital mammography (FFDM) systems, has improved breast cancer detection through enhanced lesion conspicuity and reduced tissue overlap. However, the acquisition of multiple low-dose projections raises concerns regarding cumulative radiation exposure, particularly in screening programs. In Morocco, limited published data are available on patient dose levels in DBT, highlighting the need for local dose assessment and optimization.

METHODS AND MATERIALS:

Patients aged ≥ 30 Years (30 - 82) who underwent breast

Tomosynthesis for screening or diagnosis at the National Institute of Oncology (INO), Rabat UHC.

We successfully included 100 patients with respect for their preferences and privacy

- Tomosynthesis and PACS Systems

- Microsoft Office Excel and SPSS

- Data were retrospectively collected from imaging records and DICOM files, without direct patients contact. No identifiable information was recorded, ensuring anonymity and confidentiality in accordance with Moroccan data protection law

- For prospective studies, informed consent was obtained after explaining the study objectives, benefits, and absence of risk

- The results will be used solely for scientific purposes and to improve care, particularly by optimizing Tomosynthesis practices and radiation protection.

RESULTS AND DISCUSSION

- Acquisition method: 85% automated and 15% manual
- Table 1 and 2 show that acquisition-related factors, including KV, mAs, compressed breast thickness (CBT), and the CC and MLO mammographic projections, influence the mean glandular dose (MGD) and the typical values. Variations in these factors may lead to changes in the radiation dose delivered to the breast and, consequently, affect the MGD and typical DRL values.

- The results presented in Figure.1 show a mean MGD of 1,5 mGy for the CC projection and 1,32 for the MLO. These values are within the range reported in international studies.

INTRODUCTION

Table 1: Average and Median Demographic, Acquisition, and Dosimetric Parameters

Variable	Average	Median	Standard deviation (SD)
Age	56	55	10.77
Weight	61.91	62	13.19
KV	28.4	29.15	2.23
mAs	62.57	58	22.3
MDG (mGy)	1.41	1.35	0.61
CBT (mm)	52.91	51.5	13.4

Table 2: Mean and Median MGD of CBT Classes and Typical Values for CC and MLO Views

CBT (mm)	Mean MGD (mGy) CC	Mean MGD (mGy) MLO	Median MGD (mGy) CC	Median MGD (mGy) MLO
20 - 30	0.8	0.86	0.8	0.44
30 - 40	0.81	1.1	0.83	1.1
40 - 50	1.57	1.11	1.6	1.12
50 - 60	1.7	1.34	1.61	1.3
60 - 70	2.64	2.12	2.64	1.63
Average Mean MGD (mGy)	1.5 $\pm$ 0.76	1.32 $\pm$ 0.48		
Typical Values (mGy)			1.6 $\pm$ 0.75	1.1 $\pm$ 0.43

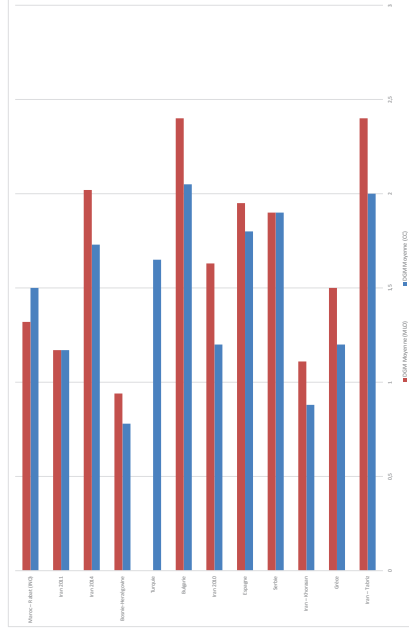


Figure.1 : CC and MLO MGD Across Our Study and International Studies

Table.3: Comparison of the Typical Values & DRLs (75th Percentiles) of Previous Studies Vs Typical Values of Our Study

This Study Typical Values CC & MLO (CBT: 50 - 70 mm)	Switzerland 2024 DRLs (CBT: 50-60 mm)	Australia 2025 CC & MLO (CBT: 50-74 mm)	France (CBT: 57 mm) National DRL	France (CBT: 57 mm) National DRL
CC & MLO: 1.8 mGy	CC: 1.79 mGy	Typical Value: 2.3 mGy	2.8 mGy	2.3 mGy
CC: 2,125 mGy	MLO: 1.91 mGy	DRL: 2.7 mGy		
MLO: 1.5 mGy				

Our typical MGD 1,8 mGy; CBT 50-70 mm was lower than the Australian typical value 2,3 mGy; CBT 50-74 mm and below its DRL 2,7 mGy. Our CC typical value 2,125 mGy was slightly above the Swiss DRL 1,79 mGy, whereas the MLO value 1,5 mGy was below the Swiss DRL 1,91 mGy.

Both projections were below the Irland DRL 2,8 mGy. Overall, our DBT dose levels were comparable to or lower than published international reference values, although differences in CBT ranges and methodologies should be considered. These finding indicate good optimization of the acquisition protocols while highlighting the importance of strengthening quality control and establishing local reference levels to further improve radiation protection in digital breast tomosynthesis. The Authors recommend using the results of this study to establish DRLs specific to the Moroccan context to DBT and to review these DRLs regulatory in response to technological developments and changes in clinical practice.

CONCLUSION:

Digital breast tomosynthesis is an effective tool for breast cancer screening but image quality must be balanced with radiation dose. Our study shows that optimizing technical parameters protocol can help reduce dose while maintaining good image quality. This work is a first step toward better dose management in Morocco and highlights the national reference levels to ensure safe and effective breast imaging.

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Quality Assurance Verification of CBCT and kV/MV Imaging Performance for IGRT

BOUKSIBA Amina

Department of Radiotherapy, Specialized Hospital for Cancer Treatment |
Béchar Algeria

bouksiba.amina17@gmail.com

Abstract

Accurate onboard imaging is essential for precise patient positioning and safe treatment delivery in image-guided radiotherapy (IGRT). A rigorous quality assurance (QA) program is therefore required to ensure stable image quality, geometric accuracy, reliable image registration, and reproducible patient positioning. This work presents a comprehensive QA assessment of the IGRT imaging and positioning workflow in a clinical radiotherapy department.

QA tests were performed according to AAPM recommendations and Elekta XVI acceptance protocols using CATPHAN 503 for CBCT image quality and geometric scaling, TOR 18FG for planar kV image quality, a Las Vegas phantom for MV low-contrast detectability, a Ball-Bearing phantom for planar geometric accuracy and isocenter verification, and MIMI and Penta Guide phantoms for image registration, table movement accuracy, positioning stability, and end-to-end IGRT verification. Evaluated parameters included image uniformity, low-contrast visibility, spatial resolution, geometric scaling, isocenter coincidence, registration accuracy, table movement accuracy, positioning stability, and end-to-end verification.

CBCT uniformity variation was 0.36% ($\leq 1.5\%$), low-contrast visibility was 1.90% ($\leq 3\%$), and spatial resolution reached 11 lp/cm (≥ 10 lp/cm). Geometric scaling measurements were 117.1 mm in both transverse directions (117 ± 1 mm) and 110 mm in the sagittal direction (110 ± 1 mm). For kV imaging, low-contrast visibility reached 13 visible discs (≥ 12), and spatial resolution reached the 14th frequency group (≥ 10 th group), while all mandatory holes were visible in the MV low-contrast assessment. Planar geometric accuracy showed a maximum deviation of 1 pixel across the evaluated gantry angles. Isocenter coincidence, image registration, table movement, positioning stability, and end-to-end IGRT tests demonstrated sub-millimetric accuracy, with residual errors up to 0.7 mm.

These results demonstrate consistent image quality, accurate geometric alignment, reliable image registration and couch correction, and reproducible positioning throughout the evaluated IGRT workflow. The comprehensive QA assessment confirms that the evaluated Elekta IGRT imaging and positioning system met the specified clinical QA criteria, supporting its safe implementation in routine high-precision radiotherapy.

Keywords: Cone-Beam CT (CBCT); Image-Guided Radiotherapy (IGRT); Quality Assurance (QA); Image Registration; Geometric Accuracy; Isocenter Verification.

References

- [1] Klein EE, et al. Task Group 142 report: Quality assurance of medical accelerators. *Med Phys.* 2009;36(9):4197–4212. doi:10.1118/1.3190392.
- [2] Bissonnette JP, et al. Quality assurance for image-guided radiation therapy utilizing CT-based technologies: A report of the AAPM TG-179. *Med Phys.* 2012;39(4):1946–1963. doi:10.1118/1.3690466.
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INTRODUCTION

Image-guided radiotherapy (IGRT) integrates onboard imaging modalities (kV, MV, and CBCT) to improve patient setup accuracy and reduce geometric uncertainties. These systems enable three-dimensional target localization and treatment verification using the accelerator isocenter as a reference. A rigorous quality assurance (QA) program is therefore essential to ensure that image quality and geometric accuracy remain within acceptable limits, maintaining the reliability of IGRT-guided treatments.

OBJECTIVES

- Evaluate the image quality performance of CBCT, kV, and MV imaging systems.
- Assess geometric accuracy, imaging–treatment isocenter coincidence, and reproducibility.
- Verify image registration accuracy and automatic couch-correction performance.
- Validate IGRT workflow reliability through complementary phantom-based end-to-end verification tests.

MATERIALS AND METHODS

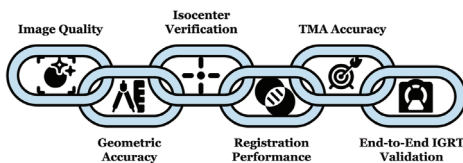
QA Protocols

- AAPM TG-142 recommendations.
- AAPM TG-179 report.
- Elekta XVI acceptance protocols.

Systems

- Elekta Infinity LINAC equipped with:
- XVI R5.0 imaging system.
 - iViewGT MV imaging system.
 - Precise Treatment Table.

IGRT QA Evaluation Framework



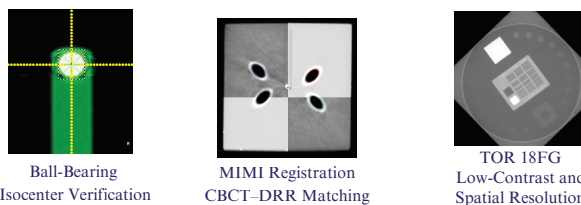
QA Approach

Complementary QA tests were integrated to ensure a comprehensive and reliable verification of the IGRT workflow.

PHANTOMS



Representative QA Images



RESULTS

Table 1. Image Quality Assessment

✓ Overall Status: All image quality parameters met the acceptance criteria.

System / Phantom	Parameter	Measured Value	Acceptance
CBCT CATPHAN 503	Uniformity	0.36%	≤1.5%
	Low-Contrast Visibility	1.90%	≤3%
	Spatial Resolution	11 lp/cm	≥10 lp/cm
kV TOR 18FG	Low-Contrast Visibility	13 discs	≥12 discs
	Spatial Resolution	Group 14	≥10th group
MV Las Vegas Phantom	Low-Contrast Detectability	All mandatory holes visible	Mandatory holes visible

Table 2. Geometric Accuracy Assessment

✓ Overall Status: Geometric accuracy was within the specified tolerance limits.

Phantom	Parameter	Measured Value	Acceptance
CATPHAN 503	Transverse Scaling	Horizontal: 117.1 mm Vertical: 117.1 mm	117 ±1 mm
	Sagittal Scaling	110 mm	110 ±1 mm
Ball-Bearing	Planar Geometric Accuracy (Gantry: 180°, 90°, 0°, -90°)	Maximum deviation (X/Y): 1 pixel	≤4 pixels

Table 3. Comprehensive IGRT Accuracy Assessment, Registration Verification and Positioning Evaluation

MIMI Phantom	Ball-Bearing	Penta Guide
Bone Match Registration V: 0.3 / Lng: 0.2 / Lat: 0.4 mm	Isocenter Coincidence V: 0.6 / Lng: 0.2 / Lat: 0.6 mm	Isocenter Coincidence V: 0.7 / Lng: 0.3 / Lat: 0.6 mm
Grey Value Match Registration V: 0.5 / Lng: 0.3 / Lat: 0.5 mm	Flexmap Registration V: 0.7 / Lng: 0.2 / Lat: 0.6 mm	CBCT Registration V: 0.4 / Lng: 0.3 / Lat: 0.5 mm
Table Move Assistant (TMA) V: 0.3 / Lng: 0.2 / Lat: 0.4 mm	Table Move Assistant (TMA) V: 0.2 / Lng: 0.1 / Lat: 0.3 mm	Table Move Assistant (TMA) V: 0.3 / Lng: 0.2 / Lat: 0.2 mm
Positioning Stability (Mean ± SD) V: 0.54 ± 0.11 / Lng: 0.44 ± 0.11 Lat: 0.60 ± 0.10 mm		
End-to-End IGRT Validation V: 0.3 / Lng: 0.4 / Lat: 0.5 mm		

V: Vertical | Lng: Longitudinal | Lat: Lateral
SD = Standard Deviation

✓ Overall Status: All isocenter coincidence, registration accuracy, TMA corrections, positioning stability, and end-to-end IGRT verification tests met the acceptance criteria.

DISCUSSION

The QA evaluation demonstrated consistent and reliable IGRT performance. Image quality supported adequate anatomical visualization, while geometric and isocenter assessments confirmed accuracy within ±1 mm. Registration and couch correction tests showed sub-millimeter accuracy, with residual errors up to 0.7 mm. Overall, complementary phantom-based tests confirmed a robust and reproducible IGRT workflow, supporting accurate patient positioning and minimizing setup uncertainties.

CONCLUSION

Our comprehensive QA assessment confirms that the Elekta IGRT system meets all clinical QA criteria. The verified imaging quality, geometric alignment, and positioning accuracy support safe and precise IGRT implementation. These results demonstrate the system's suitability for routine high-precision radiotherapy, aligning with AAPM recommendations for IGRT QA.

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- Elekta Limited. XVI R5.0 Customer Acceptance Tests. Document ID 1503162_07; 2020.

P08 Performance Evaluation of Various Radio Diagnostic Equipments in Clinical Practices

C. Senthamil Selvan¹ and C. S. Sureka²

¹ *Department of Medical Physics, State Cancer Institute, I.G.I.M.S., Patna, Bihar, India*

² *Department of Medical Physics, Bharathiar University, Coimbatore, Tamil Nadu, India*

PERFORMANCE EVALUATION OF VARIOUS RADIO DIAGNOSTIC EQUIPMENTS IN CLINICAL PRACTICES

(Data from Doctoral Research at Bharathiar University)

Dr.C.SENTHAMIL SELVAN
PRESENTING AUTHOR

Dr.C.S.SUREKA
RESEARCH SUPERVISOR
Department of Medical Physics, Bharathiar University, Tamil Nadu, India



HIGHLIGHTS

- Identified critical QA parameters for diagnostic radiology equipment.
- Performed recommended QA tests across major diagnostic X-ray modalities.
- Identified & rectified equipment malfunctions to reduce unnecessary radiation exposure.
- Assessed mammographic doses using MOSFET and OSLD technology.
- Support future regional Diagnostic Reference Level (DRL) development.

TOTAL UNITS EVALUATED
230

PASS RATE (AERB STANDARDS)
78%

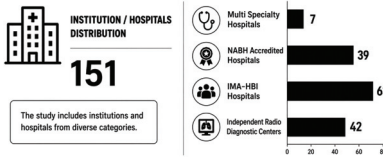
IDENTIFIED & RECTIFIED DEFECT RATE
22%

DAILY IMPACT PREEMPTED UNNECESSARY EXPOSURE FOR
~175 PATIENTS/DAY

BACKGROUND & OBJECTIVES

Diagnostic radiology must balance high quality image output with the lowest possible radiation dose to patients, staff, and the public. The primary objective was to perform combined equipment performance testing, radiation dosimetry, image quality assessment, and equipment rectification on 230 equipment units across 151 clinical institutions in Southern India in accordance with standard radiation safety guidelines set by the Atomic Energy Regulatory Board (AERB), Mumbai with free of cost.

MATERIALS & METHODS



QA protocols: AERB recommendations with relevant AAPM/IEC/ACR criteria.

Equipment Parameters: beam alignment,

focal spot, kVp, mA, timer/mAs linearity, output consistency, HVL/filtration, leakage, and radiation survey.

Dosimetry: PTW-NOMEX, RAD CAL ion chamber, OSLD nanoDot and MOSFET.

Image Quality Checks: resolution/contrast, CR/DR image assessment, CT/CBCT and mammography phantoms. Image quality assessment incorporated phantom and resolution checks.

Paediatric Phantom: PMMA soft tissue-equivalent material + hydroxyapatite bone-equivalent structures.

Modalities: Screen Film (31 Nos), Mobile (42 Nos), Mammography (13 Nos), Computed (48 Nos), Digital (22 Nos), Computed (14 Nos), Tomography (14 Nos), Cone Beam Computed Tomography (3 Nos), Simulator (1 No), Dental (19 Nos), Lithotripsy (2 Nos), C-Arm (27 Nos), and Cath Lab (8 Nos)

RESULTS & CRITICAL QA FINDINGS

SCREEN-FILM & MOBILE: 66% passed all tests; 15% failed most tests.

CR & DR: 90% passed all tests; deviations were identified in beam alignment, kVp, timer, mAs linearity, output consistency and leakage.

CT, CBCT & SIMULATOR: all 18 systems passed the reported QA tests within tolerance limits.

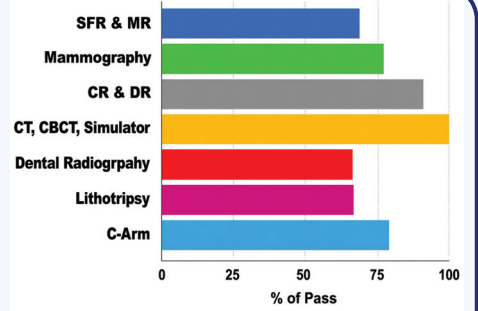
DENTAL & LITHOTRIPSY: 66% passed all tests; beam alignment and output consistency deviations were observed.

C-ARM: 77% passed all tests; beam alignment, mAs linearity, image intensifier performance and table top dose issues were identified.

MAMMOGRAPHY: 69% passed all tests; servicing materially reduced reported ESAK & AGD in the biopsy phantom assessment. Before and after servicing, the mean ESAK was 21.3 mGy and 10.36 mGy, while the calculated AGD was 4.00 mGy and 1.93 mGy, respectively.

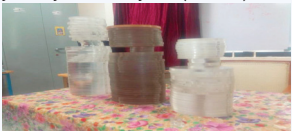
RADIATION PROTECTION: Rectifying non-compliant units prevented unwarranted exposure for approximately 175 patients daily.

CRITICAL OBSERVATION: Pediatric and women's imaging protocols (e.g., mammography, dental) frequently showed compromised quality and demand urgent prioritization. Periodic measurements allow early identification of drift, malfunction and unsafe radiation output.

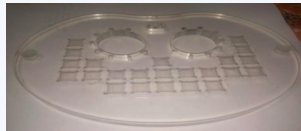


NOVEL INDIAN PEDIATRIC PHANTOM FABRICATION & DOSIMETRY

Phantom Design: Fabrication of heterogametic Indian pediatric phantoms (representing 1 year, 5 years, and 10 years old anatomical dimensions) using polymethyl methacrylate (PMMA) sheets.



Heterogametic Indian pediatric phantom

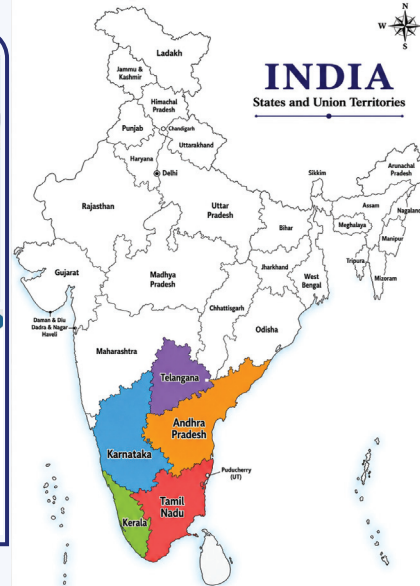
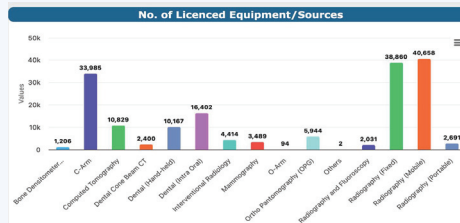
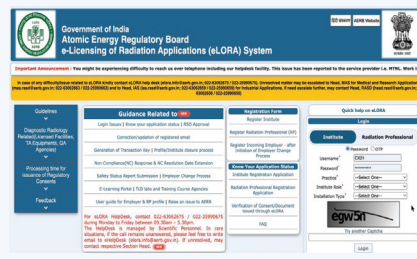


OSLD insertion in phantom slab

Validation: Verified using CT Hounsfield Units (HU) and anatomical organ densities.

Dosimetry Integration: Integrated nanoDot OSLDs within internal organ cavities (head, neck, thoracic, abdominal, and pelvic regions) to measure depth doses accurately during Digital Radiography (DR). The maximum dose measured in lung region was 3.219 mGy at 120 kVp, 150 mAs. The dose in head, neck and abdomen region was 1.049, 0.347, and 0.937 mGy respectively 10 years old phantom.

Outcome: Established baseline data to reduce pediatric diagnostic exposure without losing image contrast or detail.



CONCLUSION & FUTURE WORKS

Identifying and rectifying faulty equipment prevented unnecessary radiation exposure for approximately 175 patients per day across the evaluated institutions.

QA testing is vital to maintaining safe diagnostic standards and reducing population dose.

Unaccredited standalone diagnostic facilities require stricter surveillance compared to large accredited hospital networks.

AERB strictly monitors compliance and radiation safety via the e-Licensing of Radiation Application (e-LORA) system.

We will establish targeted QA protocols for high-sensitivity groups, particularly in pediatric and women's healthcare.

Pediatric dose assessments will be expanded across additional clinical protocols and regions. Larger multicenter datasets will be needed to establish modality- and age-specific Diagnostic Reference Levels (DRLs).

DAILY IMPACT VISUALIZATION



Preempted unnecessary radiation exposure for approximately **175** patients every day.

References & Acknowledgments :

IAEA Human Health Series No. 47, Handbook of Basic Quality Control Tests for Diagnostic Radiology (2023)
<https://elora.aerb.gov.in/ELORA/populateLoginAction.htm>
Financial Support - AERB, Mumbai & DST -SERB, New Delhi
All the hospitals/institutions in South India who supported this study.

Corresponding author e-mail :
surekasekaran@buc.edu.in

ICTP
College on Medical Physics 2026
(from 24th August to 12th September 2026)
Trieste, Italy



PATIENT DOSIMETRY IN SELECTED HOSPITALS AND INVESTIGATION OF A LOW-COST PHANTOM SUITABLE FOR QUALITY ASSURANCE MEASUREMENTS IN COMPUTED TOMOGRAPHY IN NIGERIA.

Mary-Ann E. EKPO¹, Rachel I. OBED², Godwin I. OGBOLE^{2,3}

¹Oncology Department, ASI Ukpo Memorial Hospital, Calabar, Nigeria.

²Department of Physics, University of Ibadan, Ibadan, Nigeria

³Department of Radiology, University College Hospital, Ibadan, Nigeria.

The use of ionizing radiation is one of the established medical procedures globally of which Computed Tomography (CT) contributes about 34% of the collective dose. It is therefore important to establish a functional Quality Assurance (QA) procedure in CT with relevant phantom facilities in order to reduce cancer risk to patients. This study was designed to develop a low-cost CT phantom for QA measurements and develop a regression model based of patient BMI for pre-scan protocol optimization. Data were collected on 545 patients in purposively selected seven hospitals in North-central, South-west and South-south Nigeria comprising information on 295 (54.1%) males and 250 (45.9%) females that underwent common CT examinations. These included: Head (314), Chest (86), Abdomen (145). Volume Computed Tomography Dose Index (CTDI_{vol}), Dose Length Product (DLP), organ and effective doses were calculated using standard methods. A linear correlation between Height (H), Weight (W) and Effective Dose (E) was estimated and used to obtain a linear regression model. This model was used to establish patient-specific protocol for optimisation. The physical density and Hounsfield Unit (HU) number of Carboxymethylcellulose (CMC), texapon and glycerol were measured to determine their suitability as CT phantoms. The regression model was of the form $E = 18.45 + 0.102H - 0.089W$. Physical density and HU numbers determined from materials tested for tissue-equivalence showed average density and HU of 1.60 g/cm³, 1.04 g/cm³, 1.20 g/cm³ and -483, 119, 133 for CMC, texapon and glycerol, respectively. These values are similar to HU of human tissues which makes them suitable for low-cost phantom development. The carboxymethylcellulose, texapon and glycerol materials are suitable to develop low-cost tissue-equivalent phantoms for quality assurance measurements in computed tomography.

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Mary-Ann E. EKPO, Rachel I. OBED, Godwin I. OGBOLE

ASI UKPO Comprehensive Cancer Centre, Calabar, Nigeria; University of Ibadan, Ibadan, Nigeria; University College Hospital, Ibadan, Nigeria.

Corresponding author: maryannekpo2013@gmail.com

INTRODUCTION

The increased use of 'ionizing radiation' for diagnostic imaging procedures has resulted in a corresponding increase in the usage of computed tomography in developing and emerging economies, and also the low and middle income countries. This innovation has led to anxieties over the harmful effect of radiation to humans. (Berrington & Darby, 2004). Computed Tomography as an imaging procedure contributes about 34% of the collective dose (UNSCEAR, 2010). It is therefore important to establish a functional Quality Assurance (QA) procedure in CT with relevant phantom facilities in order to reduce cancer risk to patients.

AIM AND OBJECTIVES

The aim of this study is to assess medical radiation exposure to adult patients from common CT examinations in Nigeria, estimate the risk of radiation-induced cancer and to investigate low-cost materials suitable for the development of CT phantom. The objectives are:

- Estimate average organ and effective doses using CT-ExPO software.
- Estimate risk of radiation-induced cancer for radiosensitive organs as well as the overall cancer risk estimation.
- Estimate and predict Effective dose (E) from CT with regression model using Height and Weight (BMI) of patients and establish a correlation between BMI and E for protocol optimization.
- Investigate the tissue-equivalent properties of low-cost phantom materials for quality assurance.

MATERIALS AND METHODS

Data were collected on 545 patients in purposively selected seven hospitals in North-central, South-West and South-South, Nigeria comprising information on 295 (54.1%) males and 250(45.9%) females that underwent common CT examinations. These included: Head (314), Chest (86), Abdomen (145). Volume Computed Tomography Dose Index (CTDIvol), Dose Length Product (DLP), organ and effective doses were calculated using standard methods. A linear correlation between Height (H), Weight (W) and Effective dose (E), was estimated using 'R' statistical project and used to obtain a linear regression equation. The regression equation was used to establish specific protocol for optimization (Prins et al, 2011). The Physical density and Hounsfield Unit number of Carboxymethyl cellulose (CMC), Texapon and glycerol were measured to determine their suitability as CT phantoms.

RESULTS

Table 1: Comparison of median (75th percentile) CTDI_{vol} and DLP from this study with EC and published literature.

CT exam	Parameters	This Study (2024)	Optimized (2014)	EC (2014)	Recommended (2014)	EC (2014)	Prins et al, (2011)
HEAD	CTDI _{vol}	69.32±4.8	73.1±4.2	60	52.2±10	53.2±2.5	
	DLP	3345.9±153.7	1868±175	1000	84.15±24.4	96.16±4.3	
Chest	CTDI _{vol}	21.7±12.9	22.7±6.7	30	4.4±4	12.6±4.2	
	DLP	467.1±198.3	1389±236	400	331±173	609.1±1.3	
ABD	CTDI _{vol}	27.2±3.2	32.9±5.6	35	12.6±5	12.2±4.3	
	DLP	3010.6±25.4	1802±599	800	580±240	1200.3±17.1	

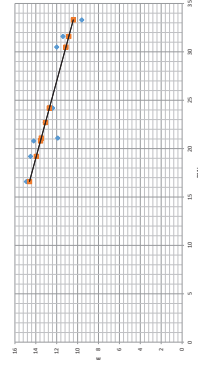
Table 2: Comparison of mean Effective Dose (mSv) with International published values.

CT exam	This Study (2024)	Optimized (2014)	Optimized (2014) at 1.2018	Optimized (2014)	EC (2014)	EC (2014)
HEAD	97.7±4.0	6.1	5.8	5.7	5.8	5.9
Chest	30.2±14.8	5.3	5.8	5.0	6.7	6.5
Abdomen	33.5±38.4		22.5	13.9	8.1	13.3

According to EC 2014, the median (75th percentile) values of the CTDI_{vol} and DLP has been proposed for the estimation of DRLs. From the table, the results of this study is only lower than the results obtained in the results from the study of Ogbole and Obad, 2014. In comparison with EC 2014, the results are slightly higher than the latter which calls for optimization of the exposure parameters.

This study has shown effective dose (E) values higher than all other compared literature values and also for EC recommended values. The Body-Mass-Index (BMI) is a quantity that expresses the ratio of an individual's height and weight. The development of the predictor equation for height and weight in the estimation of effective dose is to qualitatively estimate the effect of patient anatomical dimensions on effective dose

The regression model was of the form
E = 18.45 + 0.102H – 0.089W.



The effective dose predictor equation using the patient body-mass-index (BMI) combination shows a good correlation with the value of R² as 0.8. This equation can also be used to develop patient – specific protocols for optimisation.

Physical density and HU numbers for Carboxymethylcellulose (CMC), Texapon and Glycerol were tested for tissue-equivalence showed average density and HU of 1.60 g/cm³, 1.04 g/cm³, 1.20 g/cm³ and -483, 119, 133 for CMC, Texapon and Glycerol respectively.

CONCLUSION

This study has revealed the discrepancies in dose values as a result of differences in CT protocols among various institutions. There is a global awareness for the need for hospitals to design patient – specific protocols as well as indication – based protocols for use during CT examinations, so as to eliminate over -exposure/ under-exposure of patients.

The materials tested for tissue-equivalence carboxymethylcellulose (CMC), texapon and glycerol have shown HU numbers similar to those of human tissues, hence, their suitability for the development of a CT phantom for quality assurance measurements

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A Practical Methodological Framework for Establishing Pediatric Diagnostic Reference Levels (pDRLs) in Computed Tomography Across Low- and Middle-Income Countries.

Eddy Fotso Kamdem¹, Alain Jervé Fotue¹, Brice Bertrand Foubi Kouam³, Serge Abogo⁴, Odette Ngano Samba².

¹Condensed Matter, Electronics and Signal Processing Research Unit, Department of Physics, Faculty of Science, University of Dschang, Dschang, Cameroon. ²Department of Radiography, Yaoundé General Hospital, Yaoundé, Cameroon. ³Department of Radiology, Bafoussam Regional Hospital, Bafoussam, Cameroon. ⁴Department of Radiology, National Social Insurance Fund Hospital, Yaoundé, Cameroon..

Purpose: Diagnostic Reference Levels (DRLs) are vital radiation protection tools used to optimize patient doses and identify unusually high exposures. In most developing countries, the lack of regulatory frameworks and automated dose monitoring systems hinders the standardization of pediatric CT protocols. This study aims to propose a practical, low-cost methodological framework tailored to resource-limited settings to establish national, regional, and local pediatric DRLs (pDRLs).

Materials and Methods: A two-step strategy was established:

Initial standardization of CT protocols using European DRLs (PiDRL / EC 109) as temporary benchmarks.

Launching a multicenter national dose survey campaign co-led by medical physicists and radiologists Dosimetric parameters (CTDI_{vol} (mGy) and DLP (mGy.cm)) were collected for standard CT procedures (head, chest, abdomen). Patients were stratified by age groups for head exams (≤ 1 , 1–5, 5–10, and 10–15 years), including a minimum of 10 patients per procedure and group per facility. .

Results: National DRLs (NDRLs) were determined using the 75th percentile of the national dose distribution, while Regional and Local DRLs (RDRLs and LDRLs) were defined using the median and mean values of local data, respectively. This methodology successfully addresses data collection challenges in infants (<1 year) through multi-year aggregation. It effectively highlights dose variations across facilities and establishes optimization triggers while ensuring that diagnostic image quality is maintained.

Conclusion: This pilot study provides a feasible, reproducible framework to establish pediatric DRLs in developing countries without relying on complex digital infrastructure. It underscores the essential role of joint collaboration between medical physicists and radiologists in institutionalizing patient dose audits and enhancing pediatric radiation safety.



ABSTRACT

Purpose: Diagnostic Reference Levels (DRLs) are vital radiation protection tools used to optimize patient doses and identify unusually high exposures. In most developing countries, the lack of regulatory frameworks and automated dose monitoring systems hinders the standardization of pediatric CT protocols. This study aims to propose a practical, low-cost methodological framework tailored to resource-limited settings to establish national, regional, and local pediatric DRLs (pDRLs).

Materials and Methods: A two-step strategy was established:

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Conclusion: This pilot study provides a feasible, reproducible framework to establish pediatric DRLs in developing countries without relying on complex digital infrastructure. It underscores the essential role of joint collaboration between medical physicists and radiologists in institutionalizing patient dose audits and enhancing pediatric radiation safety.

Eddy Fotso Kamdem, Condensed Matter, Electronics and Signal Processing Research Unit, Department of Physics, Faculty of Science, University of Dschang, Dschang, Cameroon.
Email: eddyfotsokamdem@yahoo.fr

A Practical Methodological Framework for Establishing Pediatric Diagnostic Reference Levels (pDRLs) in Computed Tomography Across Low- and Middle-Income Countries.

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¹Condensed Matter, Electronics and Signal Processing Research Unit, Department of Physics, Faculty of Science, University of Dschang, Dschang, Cameroon. ²Department of Radiography, Yaoundé General Hospital, Yaoundé, Cameroon. ³Department of Radiology, Bafoussam Regional Hospital, Bafoussam, Cameroon. ⁴Department of Radiology, National Social Insurance Fund Hospital, Yaoundé, Cameroon.

CONTEXTE AND OBJECTIFS

1- Introduction et Background

- Lack of Regulatory Framework:** Most Low- and Middle-Income Countries (LMICs) lack a national regulatory framework establishing Diagnostic Reference Levels (DRLs) for medical imaging.
- Vulnerability of Pediatric Patients:** Children possess high radiosensitivity and longer life expectancy; unoptimized adult CT scanners deliver unnecessarily high absorbed doses.
- The LMIC Bottleneck:** Standard European/IAEA methods (requiring automated dose management systems and large-scale data networks) are currently unfeasible in developing nations due to fragmented, manual data and a lack of full-time Medical Physicists in hospitals.
- Key Metrics:** DRLs are not dose limits, but optimization benchmarks based on CTDIvol (mGy) and DLP (mGy.cm).

2- Objectifs of the study

- Propose a **standardized, realistic methodology** to establish Pediatric DRLs (pDRLs) in resource-limited CT facilities.
- Define practical **patient stratification rules** (Age vs. Weight) suitable for manual/hybrid data collection.
- Bridge the gap between international guidelines (EC, IAEA, ICRP) and local clinical constraints in developing countries.

METHODOLOGY

1- Two-step approach

Step 1 : Baseline Standardization: Use European DRLs (PIDRL / EC 109) as temporary benchmarks to align local CT protocols.

Step 2 : National Survey Campaign: Conduct multi-center dose collection co-led by Medical Physicists, Radiologists, and Technologists.

2-Dosimetric metrics and calibration

- CTDIvol (mGy):** Average dose in scanned volume (CTDIw / Pitch). Standard phantoms: **16 cm (Head)** and **32 cm (Body)**.
- DLP (mGy.cm):** Total energy imparted (CTDIvol x Length).

CONCLUSION

- Presence of Medical Physicists:** Lower dose values observed in Senegal are partly explained by the presence of full-time medical physicists and routine quality control (QC).
- This pilot methodology provides a **reproducible, low-cost framework** for initiating pDRLs in LMICs without waiting for fully automated digital infrastructure.
- Joint collaboration between **Medical Physicists and Radiologists** is essential to institutionalize dose audits and establish the country's first official National DRLs.
- Extension of manual/hybrid dose tracking to multi-country LMIC networks (Cameroon, Benin, Senegal).
- Advocacy for mandatory Quality Assurance (QA) programs and full-time clinical Medical Physicists in LMIC radiology departments.

Acknowledgements: Special thanks to CT technologists, participating hospitals, and the ICTP Medical Physics College.

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RESULTS AND DISCUSSION

3-Patient grouping and sample size

- Head Exams:** Grouped by AGE (≤ 1 , 1–5, 5–10, and 10–15 years)
- Sample Size:** Minimum 10 {patients} per procedure type and age/weight group per facility (multi-year collection for <1 year).

1-PDRL Calculation and hierarchy

• DRL calculations and hierarchy

✓ National DRL (NDRL) $\rightarrow$ 75th Percentile (3rd Quartile) of National Dose Surveys

✓ Regional DRL (RDRL) $\rightarrow$ Median of National Values

✓ Local DRL (LDRL) $\rightarrow$ Mean / Median of Institutional Data

8-Clinical Implementation and optimization loop

- Audit Trigger:** If Local Median Dose > NDRL (75 th percentile), initiate an immediate clinical investigation.

• Corrective Actions:

- Adjust tube current (mA) / peak voltage (kV) and activate **Automatic Exposure Control (AEC)**.
- Restrict scan length (e.g., avoid over-scanning in pediatric head trauma).

Train radiology technologists on pediatric-specific protocols.

- Diagnostic Balance:** Dose reduction **must never compromise** image quality and clinical diagnostic efficacy.

AVERAGE GLANDULAR DOSE ASSESSMENT AND DETERMINATION OF A LOCAL DIAGNOSTIC REFERENCE LEVEL IN A UNIVERSITY HOSPITAL

Gamze Güleç¹, Emine Bulur²

¹ *Radiation Safety Unit, Pamukkale University Hospital, Denizli, Türkiye*

² *Health Physics and Dosimetry Services Group, TENMAK, Ankara, Türkiye*

Breast tissue is highly sensitive to ionising radiation, and the average glandular dose (AGD) is the principal dosimetric quantity for patient risk assessment and optimisation in mammography. According to ICRP Publication 135, diagnostic reference levels (DRLs) are established using the third quartile (75th percentile) of dose distributions and serve as optimisation tools rather than dose limits [1]. The IAEA Basic Safety Standards emphasise the role of DRLs in patient dose optimisation [2].

A retrospective analysis was conducted on 59 patients (37–75 years) examined in 2025 using a Hologic Selenia Dimensions system. AGD and compressed breast thickness (CBT) values were obtained from DICOM metadata. AGD evaluation was performed using established glandular dose conversion models [3]. Patient-based mean AGD values were calculated, and descriptive statistics (mean $\pm$ SD, median, and 75th percentile) were determined. The 75th percentile was considered the local DRL candidate.

Mean AGD values were 1.45 mGy (RCC), 1.56 mGy (LCC), 1.95 mGy (RMLO), and 1.99 mGy (LMLO). Combined CC and MLO means were 1.59 mGy and 1.92 mGy, respectively. The overall mean AGD was 1.74 ± 0.62 mGy (median: 1.66 mGy), and the 75th percentile was 2.08 mGy. Higher AGD values were observed in MLO projections compared with CC, consistent with national DRL findings in Türkiye [4]. The dose distribution falls within commonly reported screening ranges [5].

The determination of local DRL (2.08 mGy) is consistent with international optimisation principles and supports institutional dose monitoring for continuous quality improvement.

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INTRODUCTION

INTRODUCTION



Breast cancer remains one of the leading causes of cancer-related mortality among women, making early detection through mammography essential for improving clinical outcomes. Because breast tissue is highly radiosensitive, optimisation of radiation dose while maintaining adequate image quality is a fundamental principle of mammographic practice. Average glandular dose (AGD) is the principal dosimetric quantity for assessing radiation risk to glandular breast tissue and is widely used for patient dose evaluation [1,2,3]. Diagnostic Reference Levels (DRLs), commonly established using the third quartile (75th percentile) of patient dose distributions, are optimisation tools rather than dose limits and support continuous quality improvement in medical imaging [4,5]. Therefore, this study aimed to evaluate AGD values and derive a local DRL for mammography examinations performed in a university hospital.



MATERIAL AND METHODS

MATERIAL AND METHOD

Study design Retrospective observational study.

Study population Fifty-nine female patients (37–75 years) who underwent mammography examinations at Pamukkale University Hospital in 2025.

Mammography system Hologic Selenia Dimensions digital mammography system. Full-field digital mammography (FFDM) was used for the RCC and LCC projections, while digital breast tomosynthesis (DBT) was used for the RMLO and LMLO

Data Collection Average glandular dose (AGD) and compressed breast thickness (CBT) values were obtained from DICOM metadata.

Statistical analysis Descriptive statistics, including mean, standard deviation (SD), median, and the 75th percentile, were calculated to evaluate AGD values and establish the local diagnostic reference level (DRL).



Figure 1. Hologic Selenia Dimensions full-field digital mammography system used in this study



RESULTS

RESULTS

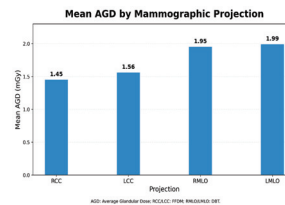


Figure 2. Mean AGD values according to mammographic projection. MLO projections showed higher AGD values than CC projections.

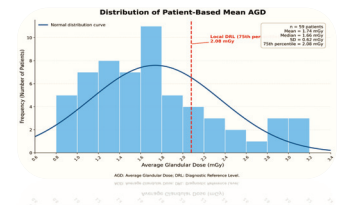


Figure 3. Distribution of patient-based mean AGD and the local DRL (75th percentile).



CONCLUSION

CONCLUSION

This study established a local diagnostic reference level (DRL) of 2.08 mGy based on patient derived average glandular dose (AGD) values obtained at our university hospital. The overall mean AGD was 1.74 ± 0.62 mGy, with a median value of 1.66 mGy. Mean AGD values were consistently higher in MLO projections than in CC projections, reflecting the influence of projection geometry and compressed breast thickness (CBT). These findings demonstrate the importance of projection-specific dose evaluation for optimizing radiation exposure in mammography.

The proposed local DRL is consistent with the dose optimization approach recommended by the IAEA and falls within the range of national mammography DRLs reported for Türkiye. The results indicate that patient doses at our university hospital are appropriately optimized while maintaining diagnostic image quality. The proposed local DRL may serve as a practical baseline for routine quality assurance, support continuous dose optimization, and contribute to the future establishment of institutional and national diagnostic reference levels for mammography.



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Multi-Institutional CT Radiomics for Stroke Patient Stratification and Clinical Characterization

Alamgir Hossain¹, Marco Esposito², Jolly Sultana³, Shahed Hossain⁴

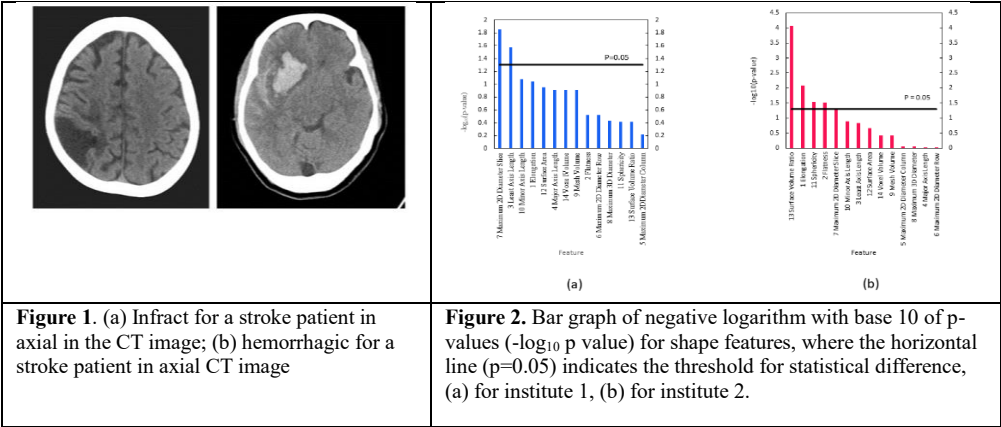
¹Medical Physics, Department of Physics, University of Rajshahi, Rajshahi-6205, Bangladesh
²Medical Physics, The Abdus Salam International Centre for Theoretical Physics, Trieste 34151, Italy
³Department of Physics, Khulna University of Engineering & Technology (KUET), Bangladesh
⁴Department of CT/MRI, Popular Diagnostic Centre Limited, Laxipur, Rajshahi-6000, Bangladesh

Introduction:

Radiomics enables the extraction of quantitative features from medical imaging, providing insights into lesion shape, intensity, and texture beyond conventional interpretation. While deep learning requires large datasets, radiomics can be applied effectively with smaller cohorts. This study aimed to investigate whether radiomic features from CT scans can distinguish between hemorrhagic and infarct strokes.

Table 1: Patient demographic information

Characteristics	Institute 1		Institute 2	
	Hemorrhage	Infra	Hemorrhage	Infra
Number of patients	46 (57%)	35 (43%)	24 (48%)	26 (52%)
Sex (P=0.312)				
Male	27 (59%)	25 (71%)	12 (50%)	14 (54%)
Female	19 (41%)	10 (29%)	12 (50%)	12 (46%)
Age (P= 0.345)				
Ranges	13-88	22-82	13-87	12-85
Mean	56.33	58.55	56.20	58.20
Median	60.50	60.36	58.40	58.20



Methods:

A total of 131 stroke patients from two institutions were included. DICOM CT scans were acquired using a Siemens 128-slice multidetector scanner at Institute 1 and a Siemens True64 CT scanner at Institute 2. Preprocessing included voxel resampling, skull stripping, and intensity normalization. Radiomic features covering shape, first-order statistics, and texture properties were extracted using 3D Slicer. Significant features were identified using Student’s t-test ($p < 0.05$), and their discriminative power was evaluated with the Area Under the Receiver Operating Characteristic Curve (AUC).

Results:

Radiomic features demonstrated significant differences between hemorrhagic and infarct strokes. At Institute 1, mean AUCs were 0.9453 for hemorrhage and 0.9203 for infarct, while at Institute 2, the corresponding AUCs were 0.9696 and 0.9623, indicating excellent diagnostic accuracy. Shape and texture features were particularly effective in differentiating stroke types.

Conclusion:

CT-based radiomic analysis shows strong potential for distinguishing between hemorrhagic and infarct strokes, supporting its use as a non-invasive diagnostic tool for stroke stratification. Despite promising results, larger datasets, standardized imaging protocols, and external validation are required to confirm clinical applicability and facilitate integration into routine practice.

Acknowledgement: We are acknowledged for providing CT data of stroke patients from Popular Clinic Ltd, Rajshahi (Institute 1) and Gazi Medical Hospital, Khulna, Bangladesh (Institute 2). Alamgir Hossain would like to acknowledge support from the ICTP through the Associates Program (2024-2029).

College on Medical Physics 2026

Introduction

1. CT radiomics extracts quantitative imaging features beyond conventional assessment.

2. This study evaluated whether CT radiomic features can distinguish hemorrhagic from infarct stroke.

Methods

1. 131 stroke patients from two institutions were analyzed.
2. CT images were preprocessed, and shape, first-order, and texture features were extracted using 3D Slicer.
3. Significant features were identified using Student's *t*-test, and AUC was used to assess discrimination.

Results

1. Significant radiomic differences were observed between hemorrhagic and infarct strokes.
2. Mean AUCs were **0.9453/0.9203** at Institute 1 and **0.9696/0.9623** at Institute 2.
3. Shape and texture features showed strong discriminatory performance.

Conclusion

1. CT radiomics demonstrated excellent potential for stroke-type differentiation.
2. Larger datasets and external validation are needed to confirm clinical applicability.

Correspondence Email:
hossain447a@gmail.com



University of Rajshahi

Introduction:

Radiomics enables the extraction of quantitative features from medical imaging, providing insights into lesion shape, intensity, and texture beyond conventional interpretation. While deep learning requires large datasets, radiomics can be applied effectively with smaller cohorts. This study aimed to investigate whether radiomic features from CT scans can distinguish between hemorrhagic and infarct strokes.

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	Hemorrhage	Infarct	Hemorrhage	Infarct
Number of patients	46 (57%)	35 (43%)	24 (48%)	26 (52%)
Sex ($P=0.312$)				
Male	27 (59%)	25 (71%)	12 (50%)	14 (54%)
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Age ($P=0.345$)				
Ranges	13-88	22-82	13-87	12-85
Mean	56.33	58.55	56.20	58.20
Median	60.50	60.36	58.40	58.20

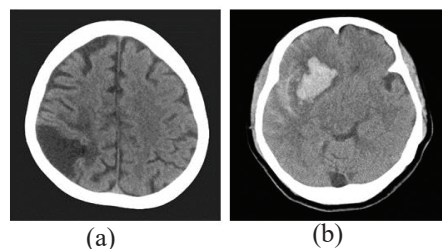


Figure 1. (a) Infarct for a stroke patient in axial in the CT image; (b) hemorrhagic for a stroke patient in axial CT image

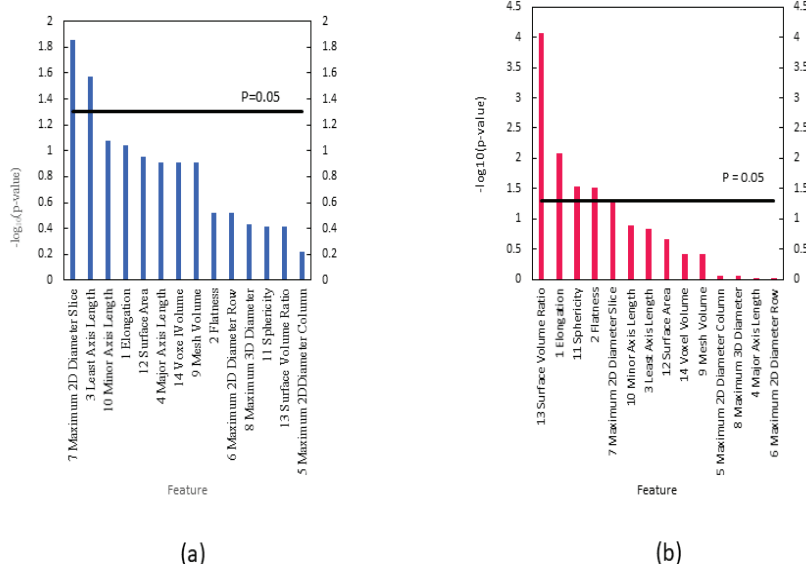


Figure 2. Bar graph of negative logarithm with base 10 of p -values ($-\log_{10} p$ value) for shape features, where the horizontal line ($p=0.05$) indicates the threshold for statistical difference, (a) for institute 1, (b) for institute 2.

Conclusion:

CT-based radiomic analysis shows strong potential for distinguishing between hemorrhagic and infarct strokes, supporting its use as a non-invasive diagnostic tool for stroke stratification. Despite promising results, larger datasets, standardized imaging protocols, and external validation are required to confirm clinical applicability and facilitate integration into routine practice.

Acknowledgement: We are acknowledged for providing CT data of stroke patients from Popular Clinic Ltd, Rajshahi (Institute 1) and Gazi Medical Hospital, Khulna, Bangladesh (Institute 2). Alamgir Hossain would like to acknowledge support from the ICTP through the Associates Program (2024-2029).

Institutional dose reference levels for common interventional cardiology procedures: a preliminary study

Sarthak Kar¹ and Satish C. Uniyal¹

¹Department of Medical Physics, Himalayan Institute of Medical Sciences, Swami Rama Himalayan University, Jolly Grant, Dehradun 248016, India

Objectives: To investigate patient radiation doses during two commonly performed interventional cardiology (IC) procedures: coronary angiography (CA) and percutaneous transluminal coronary angioplasty (PTCA) in a dedicated cardiac catheterization laboratory, and to establish institutional dose reference levels (DRLs).

Materials and Methods: The study was performed in ‘normal’ fluoroscopy mode with a digital image acquisition rate of 15 frames/second for CA and PTCA procedures. The values of dose-area product (DAP) were recorded for 808 CA and 854 PTCA procedures performed in the catheterization laboratory. The institutional DRLs for these procedures were estimated as the third quartile of the distribution of recorded DAP values for each procedure type. Also, the recorded DAP values were used to calculate the average effective dose (E_{av}) by using an appropriate conversion factor.

Results & Discussion: The recorded DAP values ranged from 0.79 to 82.49 Gy-cm² for CA and from 4.37 to 345.44 Gy-cm² for PTCA procedures. The estimated values of DRLs and E_{av} were 15 and 74 Gy-cm², and 2.34 and 10.90 mSv for CA and PTCA procedures, respectively. DRL values were in agreement with the corresponding DRLs reported in the literature.

Conclusion: The large variation in doses for both types of procedures indicates an opportunity to reduce patient exposure. The proposed DRLs may help optimize patient doses during IC procedures at the institutional level by employing appropriate dose-saving techniques in routine clinical settings.

Estimation of Radiation Exposure Based on Size-Specific Dose Estimates (SSDE) in Adult Chest and Abdomen CT Examinations on a 64-Slice MDCT System

Atul Mishra^{1*}, Satyam Verma², Rohit Sharma³, AK Srivastava⁴, Abhishek Kumar²

1Department of Radiation Oncology, Uttar Pradesh University of Medical Sciences, Saifai, Etawah (U.P.) - 206130, India

2Department of Radio-Diagnosis, All India Institute of Medical Sciences, Raebareli (U.P.), 229405, India

3Department of Radio-diagnosis, UCMS and GTB Hospital, University of Delhi, 110095, India

4Department of Radiotherapy, Sarojini Naidu Medical College, Agra (U.P.), 282002, India

Presenting and corresponding Author: Atul Mishra^{*}, Email: meetatulmishra@gmail.com

Abstract:

Introduction: Computed tomography (CT) accounts for 60–70% of the total medical radiation dose worldwide despite comprising only 20–25% of diagnostic imaging procedures. Conventional dose descriptors—CTDIvol and DLP—do not account for patient size and therefore do not represent true patient-absorbed dose. Size-Specific Dose Estimate (SSDE), based on AAPM Report 204, provides a more accurate dose metric by incorporating patient body dimensions. To determine SSDE for adult NCCT chest and abdomen scans using four measurement methods (AP, LAT, AP+LAT, and effective diameter). To assess correlation of SSDE with CTDIvol, DLP, patient age, and body size.

Materials and Methods: A cross-sectional analytical study was conducted on a 64-slice Siemens Somatom Definition AS CT system. Data of 130 adults (65 chest and 65 abdomen NCCT scans) were retrospectively evaluated. AP and LAT measurements were taken from axial images using digital calipers. SSDE was computed using AAPM Report 204 conversion factors. Correlations were assessed using Friedman and Wilcoxon tests.

Results: Mean CTDIvol and SSDE for chest scans were 5.83 ± 1.37 mGy and 9.15 ± 1.92 mGy, respectively. For abdomen, values were 8.59 ± 2.13 mGy and 13.53 ± 3.03 mGy. SSDE values significantly differed across the four measurement methods ($p < 0.01$). SSDE demonstrated a stronger correlation with patient size than CTDIvol in both chest ($r^2 = 0.23$) and abdomen ($r^2 = 0.26$). Dose levels were 36–55% lower than ACR DRLs.

Conclusion: SSDE provides a more reliable estimation of patient dose compared to CTDIvol. The lower SSDE values observed highlight appropriate protocol optimization at our centre. Routine SSDE reporting should be incorporated into CT practice in India, and national DRLs should be established.

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Diagnostic Reference Levels Based on Clinical Indications for Adult CT: A Study in a Brazilian Academic Centre

Amanda F. Nascimento¹, Denise Y. Nersissian¹ and Paulo R. Costa^{1,2}

¹ *Departamento de Física Nuclear, Instituto de Física, Universidade de São Paulo*

³ *Departamento de Radiologia e Oncologia, Faculdade de Medicina, Universidade de São Paulo*

The growing adoption of CT images in the diagnostic chain and the strong correlation between image quality and radiation dose associated to these studies reinforce the need for implementing regular optimization of clinical protocols [1]. The establishment of diagnostic reference levels (DRLs) has become one of the most effective tools for this purpose. Defined by the International Commission on Radiological Protection (ICRP) in its publication 135 [2], DRLs represent an effective approach to allow the implementation of optimization strategies in diagnostic and interventional procedures. Despite this progress, there remains a need for DRL studies that incorporate clinical indications (CIs), an approach recommended in international guidelines but still underrepresented in the literature.

This study addresses these gaps by implementing a CI-based methodology to determine Typical Values (TVs) [3] for the most frequent adult CT examinations performed at Institute of Radiology of Hospital das Clínicas (INRAD), in Brazil. By comparing dose metrics across four scanners from different manufacturers and benchmarking them against published DRLs, the proposed approach enables the identification of clinically relevant dose outliers even in the absence of comparable national data.

Radiation dose metrics and demographic information were analysed from 1382 CT studies performed between July 2022 and July 2023 across four scanners from different manufacturers. Examinations were categorized into three CIs: urolithiasis, abnormal chest findings, and headache, based on the 10th Revision of the International Classification of Diseases. These exams were stratified by patient's Body Mass Index (BMI) to determine the institutional standard patient.

TVs for CTDI_{vol} and DLP were found to be 9,1 mGy and 492,8 mGy·cm for urolithiasis, 5,6 mGy and 231,8 mGy·cm for abnormal chest findings, and 49,8 mGy and 1062,9 mGy·cm for headache, respectively. Notably, the intra-institutional comparison revealed that one specific scanner delivered doses approximately double the institutional TV for urolithiasis (18 mGy vs. 9,1 mGy), while comparisons with published DRLs suggested excessive scan lengths in specific protocols. Consequently, the proposed CI-based methodology proved superior to broad anatomical surveys by pinpointing critical dose outliers that would otherwise remain masked. These findings triggered optimization plans, demonstrating that implementing CI-based DRLs is an essential strategy for overcoming the technological challenges of ensuring radiation safety during medical exposure in large academic hospitals with heterogeneous equipment fleets.

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Introduction

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References

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Materials and Methods

Radiation dose metrics and demographic information were analysed from 1382 CT studies performed between July 2022 and July 2023 across four scanners from different manufacturers. Examinations were categorized into three CIs: urolithiasis, abnormal chest findings, and headache, based on the 10th Revision of the International Classification of Diseases. These exams were stratified by patient's Body Mass Index (BMI) to determine the institutional standard patient.

Table 1: Number of cohort studies performed by each CT scanner.

CT Scanner	Clinical Indications		
	Urolithiasis	Abnormal chest findings	Headache
CT1 (GE Discovery 750 HD)	206	104	29
CT2 (Philips Brilliance)	354	152	35
CT3 (Canon Aquilion CXL)	155	57	12
CT4 (Siemens Somatom go.Top)	199	66	13

Table 2: Adult BMI classification used to segregate patients for analysis groups [4].

Code	Classification	BMI (kg/m ²)	Clinical Indications	
			Urolithiasis	Abnormal chest findings
0	Underweight	<18.5	26	22
1	Normal	18.5-25	231	159
2	Overweight	25-30	319	114
3	Obesity I	30-35	216	67
4	Obesity II	35-40	78	10
5	Obesity III	≥40	44	7

Results and Discussion

Table 3: Typical Values of CTDI_{vol} and DLP for urolithiasis, abnormal chest findings and headache.

Dosimetric quantity	Clinical Indications		
	Urolithiasis	Abnormal chest findings	Headache
CTDI _{vol} (mGy)	9.1	5.6	49.8
DLP (mGy·cm)	492.8	231.8	1062.9

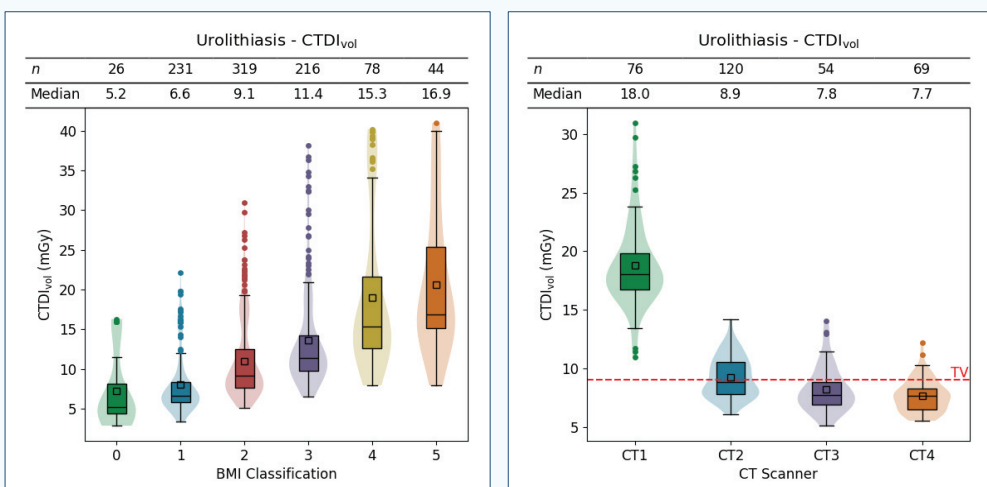


Figure 1: CTDI_{vol} distribution for urolithiasis by (a) BMI classification and (b) CT Scanner

Acknowledgements

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USE OF LEAD APRON AS SHIELD ON PATIENTS IN COMPUTED TOMOGRAPHY

Malena Taube^{1,2}, Fernando Gonzalez³, Daniel Andisco^{1,4}, Agustina Corti¹

¹*Laboratorio de Dosimetria y Protección Radiológica, Universidad Nacional de La Plata, La Plata, Argentina*

²*Centro de Investigaciones y Transferencia Santa Cruz CONICET, Santa Cruz, Argentina*

³*Hospital Interzonal General de Agudos Profesor Doctor Rodolfo Rossi, La Plata, Argentina*

⁴*Dirección Nacional del Cáncer, Ministerio de Salud Nacional, Argentina*

Introduction

Since the advent of Computed Tomography (CT), the number of CT scans performed worldwide has steadily increased, leading to a growing impact on the collective dose received by the population. Although CT accounts for less than 10% of all radiological procedures, it contributes to over 40% of the total collective dose [1]. Advances in CT technology have enabled the development of protocols for each type of examination and patient, allowing dose optimization. However, CT examinations still involve significant radiation doses, particularly concerning paediatric imaging. In these cases, lead aprons are commonly used to shield body regions not under examination, aiming to protect radiosensitive organs.

The objective of this study is to quantify the patient's variation dose due to the scatter radiation using and not of a lead apron in CT procedures.

Materials and methods

A CT scanner, a lead apron, and an ionization chamber were used. A phantom was employed to simulate the presence of a patient. Scans were performed using a brain CT protocol. The measurements were repeated for various shielding positions to evaluate the impact of apron placement on scatter radiation.

Results and conclusions

The results emphasize the importance of evaluating the use of lead aprons in CT scans. This study provides quantitative data on the variation in patient dose associated with the presence or absence of such protective measures, contributing to evidence-based decisions in radiological protection.

Key words: computed tomography, lead apron, radiological protection, ionizing radiation.

References

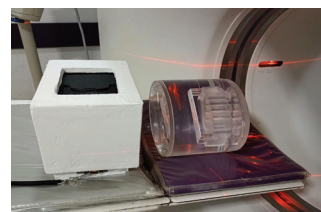
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BACKGROUND / INTRODUCTION

Since the advent of Computed Tomography (CT), the number of CT scans performed worldwide has steadily increased, leading to a growing impact on the collective dose received by the population. Although CT accounts for less than 10% of all radiological procedures, it contributes to over 40% of the total collective dose. Advances in CT technology have enabled the development of protocols for each type of examination and patient, allowing dose optimization. However, CT examinations still involve significant radiation doses, particularly concerning pediatric imaging. In these cases, lead aprons are commonly used to shield body regions not under examination, aiming to protect radiosensitive organs.

METHODS / IMPLEMENTATION

A CT scanner operating under the brain protocol ($CTDI_{vol} = 30$ mGy) was used in this study. The experimental setup included a lead apron, a Fluke 451P ionization chamber, and a custom-built Safeboard shielding box. A head phantom was employed to simulate a patient's head during exposure. Radiation measurements were performed under three different configurations: (1) the ionization chamber by itself, (2) with the lead apron covering only the upper part of the chamber and (3) with the ionization chamber fully covered (above and below) by a lead apron.



RESULTS

Measurements	mSv
Ionizing chamber itself	2.27
Upper lead apron	2.2
Up and down lead apron	2.2

RESULTS

A difference of approximately 3% was observed between measurements performed with and without the lead apron. To further investigate this discrepancy, unidirectional dose measurements were conducted. For this purpose, a shielding enclosure was constructed for the ionization chamber, providing attenuation equivalent to 0.5 mm of lead (Pb) and exposing only its most sensitive face. This setup enabled the assessment of the spatial distribution of radiation at the measurement point under controlled directional conditions.

Unidirectional Dose Contribution	
Behind	0.2%
Up	0.7%
Down	1.2%
Left	0.5%
Right	0.5%

The results underscore the need to critically assess the use of lead aprons in CT procedures. No significant differences were detected between measurements taken with and without the lead apron, regardless of whether the chamber was fully or partially covered. These findings suggest that the majority of radiation absorbed by the patient arises from internal scatter within their own body, rather than from secondary scatter originating from surrounding surfaces such as walls, ceiling, or floor.

CONCLUSIONS

- A 3% variation was observed between measurements conducted with and without the use of a lead apron.
- The application of a lead apron to shield the patient's body during cranial CT is generally considered unnecessary, as the protective benefit it offers is minimal.
- Among the unidirectional measurements evaluated, the highest contribution to the scattered radiation dose originated from the floor; however, this accounted for only 1.2% of the total dose.

Characterization of 3D printed tissue equivalent plastic materials for radiotherapy quality assurance

E. Uwitonze^{1,2}, C. Mozzi^{3,4}, R. Lanzillotta^{1,5}, M. Avanzo⁶, S. Bianucci¹, D. Cortis⁸, F. Lizzi¹, L. Marini^{1,5}, L. Marrazzo^{3,4,7}, D. Orlandi⁸, S. Pallotta^{3,4,7}, G. Pirrone⁶, A. Retico¹, D. Tatananni⁸, C. Talamonti^{3,4,7} and A. C. Kraan¹

¹*Istituto Nazionale di Fisica Nucleare (INFN), Sezione di Pisa, Italy*

²*Rwanda Cancer Centre (RCC), Kigali, Rwanda*

³*University of Florence, Italy*

⁴*Istituto Nazionale di Fisica Nucleare (INFN), Sezione di Firenze, Italy*

⁵*University of Pisa, Italy*

⁶*Centro di Riferimento Oncologico di Aviano (CRO) IRCCS, Italy*

⁷*Azienda Ospedaliero Universitaria Careggi, Firenze*

⁸*Laboratori Nazionali del Gran Sasso, L'Aquila, Italy*

Patient-specific phantoms produced using 3D printing technology are important for radiotherapy quality assurance (QA). Compared to commercial phantoms, they are more cost-effective and can replicate individual patient anatomy. This can be particularly useful to test innovative techniques such as deep learning (DL)-based treatment monitoring [1]. A key challenge in the development of 3D printed phantoms is selecting suitable materials [2, 3]. This study evaluates various 3D printing materials for patient-specific QA in X-ray radiotherapy, with a particular focus on identifying a human soft-tissue-equivalent material.

Various small cubes of ABS, PET-G, PET-GF, PLA, PPA-GF, PA12 CF and ASA were printed at Laboratori Nazionali del Gran Sasso (LNGS) using Raise3D Pro printer. Moreover, ABS, PET G, PLA and TPU were printed at INFN Pisa using Bambu Lab printer, and 15 cubes were produced by BIO3DModel using Stratasys printer. To evaluate imaging response relative to human tissues, 120 kV CT images were acquired at the Careggi hospital in Florence. For each sample, the average Hounsfield Units (HU), mass density, electron density (ED), and relative electron density (RED) were determined and compared with ICRU reference data for human tissues. To assess the response under therapeutic (MeV) X-rays, point-dose measurements were performed using a micro-diamond ionization chamber, and were compared with the Monaco TPS predictions.

Materials from LNGS and INFN Pisa exhibited HU values ranging from -93.5 to 78.3, with the exception of PET GF, which showed an HU of 229.4, while Bio3DModel materials, HU values ranged from -16.8 to 804.5. The mass density of the LNGS and INFN Pisa samples ranged from 0.98 to 1.23 g/cm³, the ED ranged from 3.13 to 3.80×10²³ and the RED ranged from 0.94 to 1.23. The Bio3DModel materials showed mass densities between 1.02 and 1.26 g/cm³. The deviation between the measured and the predicted dose by the TPS was between 0.9% and 1.2%. We identified various materials, that complied with ICRU soft tissue specifications, printed at INFN Pisa and LNGS, as well as the lightest Bio3DModel.

3D printing has an enormous potential in medical phantom development. Several candidate plastic materials were identified that realistically simulated soft tissues, many of which can be printed with moderately priced 3D printers. In the future, we will produce several 3D printed phantoms and use them to validate a DL-based treatment verification technique developed by our research group.

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E. Uwitonze^{1,2}, C. Mozzi^{3,4}, R. Lanzillotta^{1,5}, M. Avanzo⁶, S. Bianucci¹, D. Cortis⁸, F. Lizzi¹, L. Marini^{1,5}, L. Marrazzo^{3,4,7}, D. Orlandi⁸, S. Pallotta^{3,4,7}, G. Pirrone⁶, A. Retico¹, D. Tatananni⁸, C. Talamonti^{3,4,7} and A. C. Kraan¹

¹ Istituto Nazionale di Fisica Nucleare (INFN), Sezione di Pisa, Pisa, Italy, ²Department of Radiation Oncology, Rwanda Cancer Centre (RCC), Kigali, Rwanda, ³ University of Florence, Florence, Italy, ⁴ Istituto Nazionale di Fisica Nucleare (INFN), Sezione di Firenze, Firenze, Italy, ⁵ University of Pisa, Pisa, Italy, ⁶ Centro di Riferimento Oncologico di Aviano (CRO) IRCCS, Aviano, Italy, ⁷ Azienda Ospedaliero Universitaria Careggi, Firenze, ⁸ Laboratori Nazionali del Gran Sasso (LNGS), L'Aquila, Italy

Introduction

3D printing is an additive manufacturing (AM) technique which takes a 3D digital object and creates a 3D physical object, eg., radiotherapy phantoms [1].

- 3D printing uses low-cost materials
- 3D-printed phantoms are extremely adaptive → ability to represent complex geometries (human anatomy).
- **Major limitation:** difficult to find good materials (radiologically/physically equivalent, cheap, easily available, easy to handle, long-term stability).
- **Possible solution:**
 - various plastic filaments- and resin-based polyjet printer materials were tested
 - 100% filled and materials with filling density <100% were investigated (Figures 3, 4).
- **Challenge for radiotherapy phantom:**
 - physical and radiological properties should reproduce human tissues at CT X-ray energies (~100 keV) and at radiotherapeutic (MeV) X-ray energy
 - Different energies imply different interactions (Figure 1).

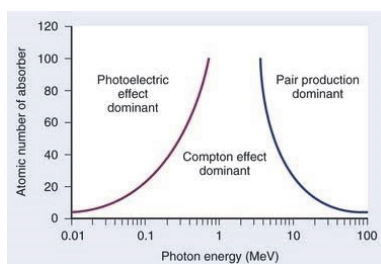


Figure 1. Photoelectric effect and Compton scattering.

Research objective

- To identify and characterize polymer materials suitable for 3D-printed tissue-equivalent phantoms
- To 3D print a simple **breast phantom** (for testing an AI-model for portal dose reconstruction)

Materials & Methods

- We 3D printed various cubes using 3 different printers.
- We weighed the cubes to allow mass density, electron density and relative electron density calculations.
- We acquired their CT images to allow HU measurements.
- We performed TPS simulations and point dose measurement and compared them to confirm the radiological accuracy of the cubes.
- We validated our materials by comparing with ICRU report 44 tissues [2].

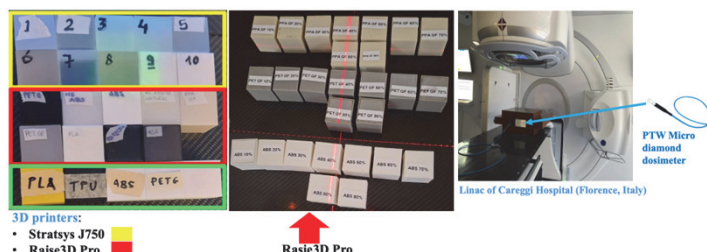


Figure 2. Data analysis workflow

Results

- Excellent agreement between TPS and measurement (Table 1), implying that our materials can respond to radiation as human tissues do.
- Several tissues could be simulated (Figures 3, 4).

Table 1: TPS dose simulations and point dose measurements.

3D printer type	Materials	D_{TPS} [cGy]	$D_{measured}$ [cGy]	Δ_D [%]
Raise3D Pro	PET G	237.7 ± 3.6	237.3 ± 0.009	-0.17
	HS ABS	234.6 ± 3.2	234.8 ± 0.004	0.10
	ABS	240.2 ± 3.3	237.0 ± 0.003	-1.34
	HS ABS v2 natural	238.0 ± 3.5	235.9 ± 0.002	-0.89
	PPA GF	236.0 ± 3.4	239.2 ± 0.004	1.36
	PET GF	235.1 ± 3.0	237.2 ± 0.006	0.90
	PLA	232.6 ± 3.5	235.4 ± 0.000	1.20
	PA12 CF	235.2 ± 3.1	235.5 ± 0.000	0.12
Bambu X1E	ASA	240.0 ± 3.2	237.7 ± 0.008	-0.94
	PLA	230.7 ± 3.2	232.8 ± 0.000	0.89
	TPU	237.2 ± 3.5	236.4 ± 0.001	-0.35
	ABS	234.8 ± 3.2	235.1 ± 0.004	0.12
	PET G	236.3 ± 2.9	236.8 ± 0.006	0.22

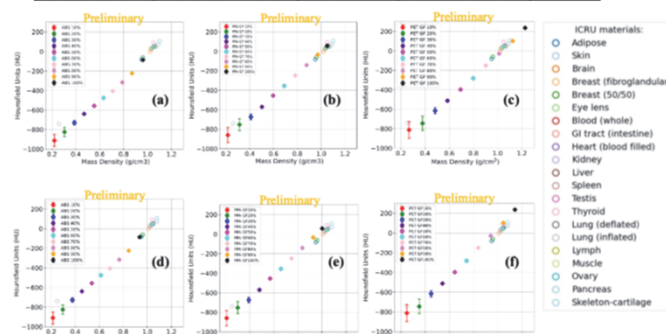


Figure 3. Identification of partially-density-filled materials.

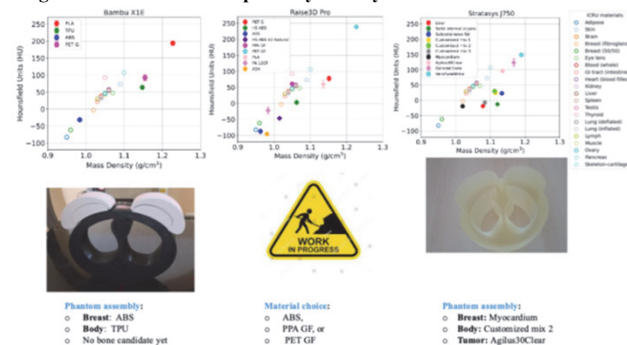


Figure 4. A simple 3D printed breast phantom.

Conclusions

- By combining CT-based material characterization with dosimetric validation, several cost-effective polymer materials were identified for the fabrication of realistic radiotherapy QA phantoms.
- For making CT-based complex phantom, it is probably easiest to vary the in-fill densities.
- The approach may facilitate broader adoption of patient-specific QA tools using accessible 3D printing technologies.

Acknowledgments

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ARTEMIS: Artificial Intelligence in RadioTherapy with EPID Monitoring System

InTRePID: In vivo 3D dosimetry in radiotherapy Treatments with EPID

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EMPOWERING YOUNG MINDS THROUGH STEM EDUCATION: ENGAGING HIGH SCHOOLERS IN GHANA THROUGH MEDICAL PHYSICS

Afua A. Yorke¹, Mercy T. Schandorf², Abigail N. M. Quaye³, Peniel Tenkorama⁴,
Bishwambhar Sengupta¹, Kwadwo Nkansah-Poku⁵, Juliana A. Kplorfia⁶, Jessica
Fagestrom¹

University of Washington Fred Hutch Cancer Center, Seattle, Washington, USA¹,
University of Ghana Medical Center, Accra, Ghana², Komfo Anokye Teaching
Hospital, Oncology Directorate, Kumasi, Ghana³, Global Communities, Accra, Ghana⁴,
University of Ghana Medical School, Accra, Ghana⁵, Girls Excellence
Movement, Accra, Ghana⁶

Purpose: To empower and promote diversity in Science, Technology, Engineering, and Mathematics (STEM), an educational presentation and hands-on session were organised to raise awareness of STEM career opportunities among girls. This initiative aimed to introduce high school students to the field of medical physics.

Materials and Methods: The study involved 65 first-year Senior High School girls, aged 13-16, pursuing general science in Accra, Ghana. This initiative, organised by the Girls Excellence Movement (GEM) in collaboration with a US institution, implemented the 'heroes in radiation oncology' program, which included a relatable presentation and hands-on experience in simulation to treatment planning activities. The program's effectiveness was assessed through pre-and post-assessment surveys, and a thematic analysis of student feedback.

Results: Participants' awareness of career fields showed an interest in traditional healthcare professions (92%) and engineering (73.8%), with minimal medical physics awareness (23%). Post-presentation survey showed a significant change in participants' perception of medical physics 87.3%. Thematic analysis revealed increased awareness, understanding, and interest, dispelled misconceptions about radiation safety and highlighted the interdisciplinary nature and career opportunities. The presentation was successful in inspiring participants and expanding their perspectives on medical physics.

Conclusion: The program raised awareness of medical physics among participants, many of whom were previously unfamiliar with the field. Participants reported a newfound understanding of the interdisciplinary nature of medical physics, its connections to biology, mathematics, and engineering. This program can easily be reproduced in community and school outreaches.

Atua A. Yorke¹, Mercy T. Schandorf², Abigail N. M. Quaye³, Peniel Tenkoramba⁴, Bishwambhar Sengupta¹, Kwadwo Nkansah-Poku⁵, Juliana A. Kporflia⁶, Jessica Fagestom¹

¹University of Washington Fred Hutchinson Cancer Center, Seattle, Washington, USA; ²University of Ghana Medical Center, Accra, Ghana; ³Komfo Anokye Teaching Hospital, Oncology Directorate, Kumasi, Ghana; ⁴Global Communities, Accra, Ghana; ⁵University of Ghana Medical School, Accra, Ghana; ⁶Girls Excellence Movement, Accra, Ghana

ABSTRACT

Purpose: To empower and promote diversity in Science, Technology, Engineering, and Mathematics (STEM), an educational presentation and hands-on session were organised to raise awareness of STEM career opportunities among girls. This initiative aimed to introduce high school students to the field of medical physics.

Materials and Methods: The study involved 65 first-year Senior High School girls, aged 13–16, pursuing general science in Accra, Ghana. This initiative, organised by the Girls Excellence Movement (GEM) in collaboration with a US institution, implemented the 'heroes in radiation oncology' program, which included a reliable presentation and hands-on experience in simulation to treatment planning activities. The program's effectiveness was assessed through pre- and post-assessment surveys, and a thematic analysis of student feedback.

Results: Participants' awareness of career fields showed an interest in traditional healthcare professions (92%) and engineering (73.8%), with minimal medical physics awareness (23%). Post-presentation survey showed a significant change in participants' perception of medical physics 87.3%. Thematic analysis revealed increased awareness, understanding, and interest, dispelled misconceptions about radiation safety and highlighted the interdisciplinary nature and career opportunities. The presentation was successful in inspiring participants and expanding their perspectives on medical physics.

Conclusion: The program raised awareness of medical physics among participants, many of whom were previously unfamiliar with the field. Participants reported a newfound understanding of the interdisciplinary nature of medical physics, its connections to biology, mathematics, and engineering. This program can easily be reproduced in community and school outreaches.

CONTACT

Mercy Torshe Schandorf, MPH
Imaging Department
University of Ghana Medical Centre
Email: mschandorf@ugmc.ug.edu.gh

INTRODUCTION

- In many low-income countries, particularly in Africa, girls face limited exposure and significant barriers to pursuing careers in Science, Technology, Engineering, and Mathematics (STEM).
- Cultural norms, lack of mentorship, and societal expectations contribute to this underrepresentation, with only 18.3% of researchers in Ghana being women.¹
- Research shows that girls' interest in STEM is influenced by self-efficacy, early learning experiences, and the presence of relatable role models.²
- To bridge this gap, organizations like the Mastercard Foundation, Girls Excellence Movement (GEM), Women in Nuclear (WIN), and others are promoting STEM through camps, mentoring, and outreach programs.
- These initiatives aim to foster awareness, challenge stereotypes, and empower young girls to pursue scientific careers.

METHODS AND MATERIALS

- This study used a mixed-methods approach to evaluate the impact of the "Heroes in Radiation Oncology" outreach program on high school girls aged 13–16 in Accra, Ghana. **See Figure 1 & 2**
- Pre-assessment surveys measured students' baseline awareness of medical physics and factors influencing career choices, including job security and cultural perceptions.
- The program included interactive sessions using storytelling, superhero themes, and visual aids like linear accelerator models, DNA replicas, and radiotherapy head masks to simplify complex scientific concepts.
- Students participated in group-based, hands-on activities from mock CT simulations to treatment planning using 2D axial images and plastic ray models, promoting collaboration and real-world learning.
- Post-session surveys revealed increased knowledge, interest in STEM careers, and a better understanding of medical physics and radiation oncology.

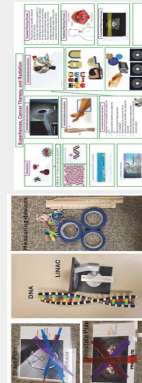


Figure 1. Illustrative items from the "Superhero in Radiotherapy" workshop.

RESULTS

- Sixty-five first-year high school girls (aged 13–16) participated in the outreach program.
- Prior to the intervention, only 23% were aware of medical physics as a career option, with most students expressing interest in more traditional health and engineering careers. **See Figure 3**
- Following the introduction, awareness of medical physics increased dramatically to 87%.
- Thematic analysis shown in **Table 1** of post-survey feedback revealed improved understanding of the field's interdisciplinary nature, increased interest in pursuing medical physics, and dispelled misconceptions about radiation safety.

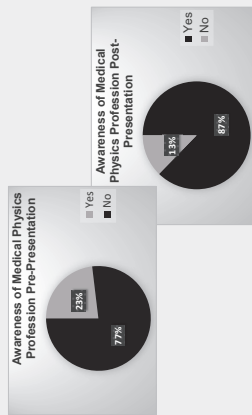


Figure 3. Change in participants' awareness of the medical physics profession before and after a presentation and hands-on activities.

DISCUSSION

- This initiative demonstrated a significant impact on participants' awareness and perception of medical physics.
- The dramatic increase in awareness from 23% to 87% highlights the effectiveness of targeted educational interventions in introducing underrepresented fields to young students.
- Student feedback revealed not only increased interest but also a clear shift in mindset, many who previously associated physics with difficulty or irrelevance expressed newfound enthusiasm and curiosity.
- Importantly, the responses also highlighted ongoing concerns such as radiation safety, job prospects, and societal support which reflect broader structural challenges in STEM engagement across low-resource settings.

Table 1. Some Thematic Analysis of responses from participants after Superheroes in radiotherapy workshop

Theme	Description	Example Quotes
Increased Awareness of Medical Physics	Participants reported an enhanced understanding of the field.	"I didn't know physics could be used to diagnose diseases such as cancer." "Did not know about such a profession and limited science professions but now, I have a further idea."

Table 1 continuation. Some Thematic Analysis of responses from participants after Superheroes in radiotherapy workshop

Theme	Description	Example Quotes
Career Opportunities in Medical Physics	Recognition of the diverse career paths in the field.	"There are more career opportunities in physics background, not just being a physics teacher." "That I can only be a doctor if I learn physics, but I can be a radiation physicist."
Role of Radiation in Medical Applications	Highlighted knowledge about medical uses of radiation.	"Learning how radiation is used in CT scans reflected on a patient to see cancer cells in the body." "Knowing how medical physics helps in curing cancers in all parts without hurting the healthy organ."
Changed Perception of Risk and Safety	Shifts in perceptions about the safety of working with radiation.	"It helped me understand that medical physics is not a risky work to do because the radiation worked with doesn't affect the workers." "The radiation a person gets from eating a banana is more than the radiation someone gets from taking a CT scan once a year."
Increased Interest in Medical Physics	Growing interest in pursuing medical physics as a career or field of study.	"It has encouraged me to pursue medical physics." "I have a better interest in medical physics." "I thought it was difficult and kind of boring, but now I think it's interesting and cool."
Understanding of Interdisciplinary Nature	Recognition of the integration of other sciences with physics in medical physics.	"I learnt that biology and math are also needed in their work." "They need all other areas of science, including physics."

CONCLUSIONS

- The initiative demonstrated that early, relatable STEM engagement can inspire underrepresented students to explore new academic and career paths.
- Future programs should focus on sustained mentorship, curriculum integration, and local role models to reinforce this interest and help build a more diverse pipeline for medical physics and other STEM fields.

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COMPARATIVE ASSESSMENT OF AVERAGE GLANDULAR DOSE IN DIGITAL BREAST TOMOSYNTHESIS AND FULL-FIELD DIGITAL MAMMOGRAPHY IN OMAN

N. Al Maymani¹, R. Al Mamari², A. Al Jabri³, S. Kheruka¹, N. Al Makhmari¹, H. Al Saidi¹, S. Al Rashdi¹, A. Al Balushi¹

¹ Radiology and Nuclear Medicine Department, Sultan Qaboos Comprehensive Cancer Care and Research Centre (SQCCRC), University Medical City, Muscat, Oman.

² Physics Department, College of Science, Sultan Qaboos University, Muscat, Oman.

³ Radiology and Molecular Imaging Department, College of Medicine, Sultan Qaboos University, Muscat, Oman.

ABSTRACT

Background: With the integration of Digital Breast Tomosynthesis (DBT) into breast imaging, there has been a significant advancement in the capabilities of Full-Field Digital Mammography (FFDM) for early breast cancer detection. However, the increased use of DBT raises concerns regarding radiation exposure levels.

Objective: This study seeks to determine diagnostic reference levels (DRLs) at the Sultan Qaboos Comprehensive Cancer Care and Research Centre (SQCCRC) for both FFDM and DBT across different compressed breast thicknesses (CBT), contributing to enhanced understanding of radiation dosimetry in breast cancer diagnosis.

Methodology: Data including average glandular dose (AGD), kVp, mAs, entrance surface dose (ESD) and CBT were retrospectively collected on FFDM and DBT exams. For seven CBT groups ranges from 20 mm to 89 mm, the mean, median, range and 75th percentile of AGD values were determined for craniocaudal (CC) and mediolateral oblique (MLO) views. The differences in AGD values between FFDM and DBT were analyzed, and correlations among AGD and CBT, kVp, mAs and ESD were investigated.

Results: Across all CBT ranges, AGD values for DBT were (1.3±0.10) higher than those for FFDM. The DRLs at SQCCRC range from 0.70 mGy to 2.55 mGy for FFDM and 0.94 mGy to 3.67 mGy for DBT. Fig. 1. The AGD highly showed correlation with kVp, mAs, ESD and CBT. A significant difference in the AGD value was noticed between FFDM and DBT acquisition in both CC and MLO projections (p < 0.005).

Conclusion: The study confirms that DBT generally results in higher AGD levels than FFDM across various CBT ranges, aligning with those established internationally. This research highlights the need for balancing radiation exposure with diagnostic accuracy in clinical decision-making, reinforcing DRLs as a benchmark for radiation safety in breast cancer screening practices.

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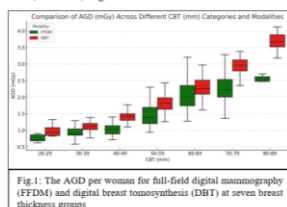


Fig.1: The AGD per woman for full-field digital mammography (FFDM) and digital breast tomosynthesis (DBT) at seven breast thickness groups