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Journal of Behavioral Informatics Digital Humanities & Development Research
Vol 11, No 2, June 2025 Series

Patient Dose From Mammographic Procedure at a Teaching Hospital In Nigeria - Validation of Displayed Dose Report

[a]Akinlade, Bidemi Idayat, [c]Olaniyi, Adenike Justina & [b]*Aborisade, Caleb Ayoade
[a]Dept of Radiation Oncology, College of Medicine, University of Ibadan, Ibadan, Nigeria
[b]Dept of Physics and Science Lab Tech, Abiola Ajimobi Technical University, Ibadan, Nigeria
[c]Department of Physics, University of Ibadan, Ibadan, Nigeria.
*Corresponding author's E-mail address: aborisadecaleb@gmai.com

ABSTRACT

Introduction: Benefits of ionizing radiation in medicine are enormous but not without a risk. Breast cancer is the most frequently diagnosed cancer among women and the second leading cause of cancer-related deaths worldwide. Strategies to reduce its burden include early detection and accurate diagnosis with radiation. Average-Glandular-Dose (AGD) received by the mammary glands is used to quantify the risk associated with mammography procedure. Some mammography units have inbuilt devices that calculate and display radiation dose received by patients, but these have to be validated to ensure accuracy and correctness. This study aims at comparing machine displayed dose reports with measured dose at the University College Hospital (UCH), being one of the few centres that offer mammography services at Ibadan, Oyo State, Nigeria. Relevant information of 112 patients, who undergone mammography procedure at UCH were retrieved from x-ray unit's storage device. These include, exposure factors, Entrance Surface Exposure (ESE) and AGD for Cranio-Caudal (CC) and Medio-Lateral Oblique (MLO) views. Thereafter, the accuracy of the most commonly selected exposure factors and beam output—used for estimating radiation doses—was measured from the mammography unit using Gammex300 Diavolt kVp meters. Both the AGD displayed and measured were compared with the international recommended values. While the AGD (mGy) measured (0.74±0.41) was higher (45%) than the displayed (0.41±0.08), both and the actual received by patients (1.32-1.82) are within the recommended 3Gy. The observed variations could be due to difference in applied compression force (breast thickness) between the actual patient and the phantom used during measurements.

Keywords: Mammography, Digital X-ray unit, Average Glandular Dose (AGD), exposure factors, Breast cancer. Entrance Surface Exposure, Breast projection views

Journal Reference Format:
Akinlade, Bidemi Idayat, Olaniyi, Adenike Justina & Aborisade, Caleb Ayoade (2025): Patient Dose From Mammographic Procedure at a Teaching Hospital In Nigeria - Validation of Displayed Dose Report. Journal of Behavioural Informatics, Digital Humanities and Development Rese Vol. 11 No. 2. Pp 41-46 https://www.isteams.net/behavioralinformaticsjournal
dx.doi.org/10.22624/AIMS/BHI/V11N2P4

1. INTRODUCTION

Breast cancer is the most prevalent cancer among women and ranks as the second leading cause of cancer-related deaths worldwide [1-2]. An estimated 670,000 deaths globally in 2022 were attributed to breast cancer [1, 2]. Although the precise causes of breast cancer remain largely unknown, key strategies to reduce its burden include increased awareness, early detection,

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accurate diagnosis, timely treatment, and access to palliative care. Studies have shown that early screening and diagnosis, combined with advances in treatment, can lead to improved outcomes and longer survival for women affected by the disease [3]. According to the World Health Organization, some countries have witnessed a significant reduction in breast cancer mortality—by as much as 30–40%—due to the widespread use of mammography as an effective screening tool [1]. In Nigeria, however, the burden of breast cancer remains particularly severe. Limited access to advanced medical infrastructure and inadequate screening programs results in many women being diagnosed at later stages of the disease, when curative treatment is no longer viable. The lack of widespread mammography screening continues to pose a major obstacle to early detection and is a key contributor to the country's high breast cancer mortality rate [4]

The average glandular dose (AGD) used to estimate radiation risk from mammography is not a quantity that can be measured directly during the procedure [5] and most diagnostic centres in Nigeria do not usually measure it. There is a pressing need for the development of local guidelines and training programs to ensure safe and effective use of mammography. Moreover, given the variability in breast tissue density among Nigerian women, personalized screening strategies that consider these differences are crucial.

Also, while optimizing the breast cancer screening program to maximize early detection it is important to minimize radiation risks and false positives [6], particularly in a limited radiation resources settings like Nigeria. This necessitates the development of more accurate risk assessment tools for radiation exposure and the implementation of tailored screening protocols that consider individual patient characteristics such as age and breast tissue density [7]. During mammography procedure, patients breasts are exposed to certain amounts of radiation dose and at times, some of the exposure parameters, when measured independently, sometimes exceed the set values recommended by the international organizations for patient safety [8]. Such instances of overexposure raised concerns regarding the potential health risks posed to patients undergoing mammography screening. Excessive radiation exposure during mammography can increase the risk of radiation-induced carcinogen, contributing to long-term health complications such as breast cancer development. Additionally, overexposure may lead to unnecessary patient anxiety and healthcare costs associated with follow-up procedures to address false positive results or other adverse effects [9].

Furthermore, inconsistent adherence to recommended exposure parameters can undermine the effectiveness of mammography screening programs by compromising the accuracy and reliability of diagnostic results [6]. This not only jeopardizes patient safety but also hampers efforts to detect breast cancer at early stages when treatment outcomes are most favorable. The issue of radiation dose exceeding recommended levels is particularly significant in regions with limited access to advanced medical facilities and resources, where adherence to safety guidelines may be challenging [10]. Without appropriate measures to address this problem, the benefits of mammography screening in detecting breast cancer early and reducing mortality rates may be overshadowed by the potential risks associated with radiation exposure.

This study aims at comparing the dose reports displayed during mammography procedure with measured doses at the University College Hospital (UCH), Ibadan, Oyo State Nigeria.

2. MATERIALS AND METHODS

This study was conducted at the University College Hospital, Ibadan, Oyo State. The digital mammogram x-ray unit used for mammography examinations of 112 patients considered was GE SCS, model 5505708, manufactured in 2022 by Ralco Medical System. Relevant information retrieved from the unit's storage devices include Exposure factors (mAs, kVp), Entrance Surface Exposure (ESE), Average Glandular Dose (AGD), breast thickness and Dose-Area Normalized (DAN). The breast projections include Right Craniocaudal (RCC), Left Craniocaudal (LCC), Right Mediolateral Oblique (RMLO), Left Mediolateral Oblique (LMLO). The accuracy and reproducibility of most selected sets of exposure factors were measured with Gammex 300 Diavolt kVp meters, placed at the x-ray beam central axis, at the Focus to Detector Distance (FDD) of 100 cm. Also measured are the beam output per mAs and Entrance Skin Exposure (ESE). The AGD for each projection was estimated from the beam output and Dance conversion factors [11, 12].

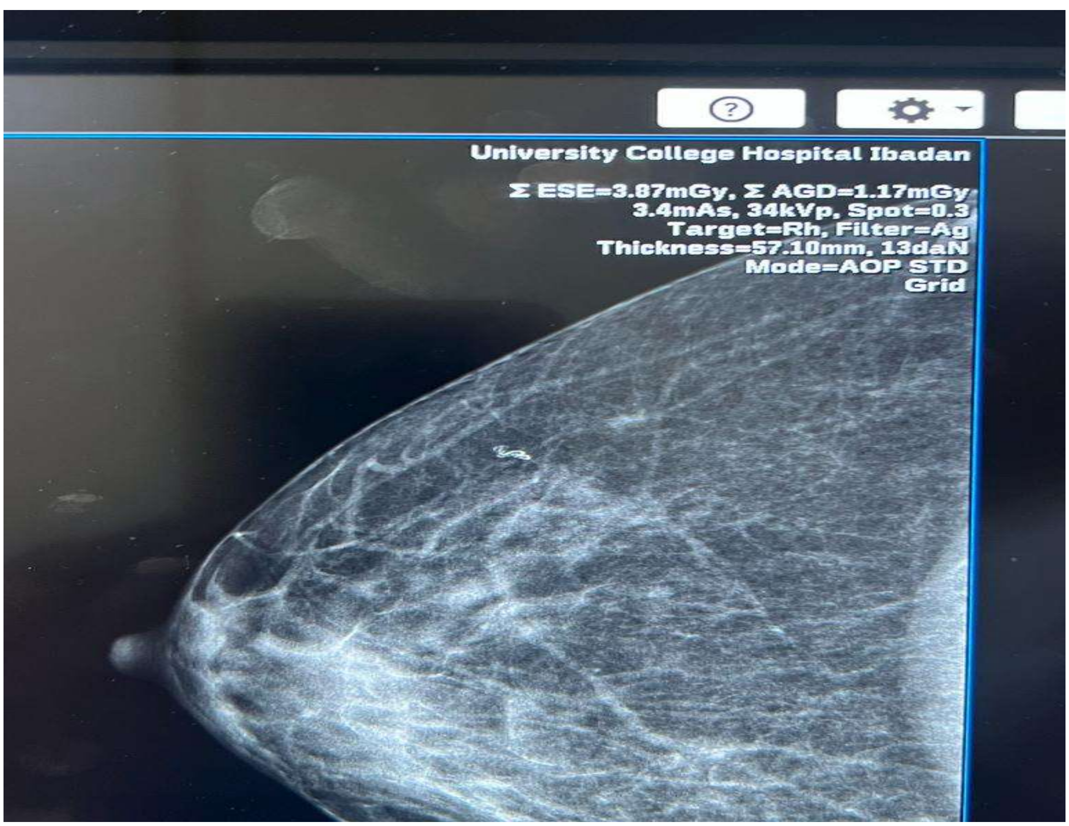

Fig1: Sample of a Breast Mammogram Atuch, Ibadan

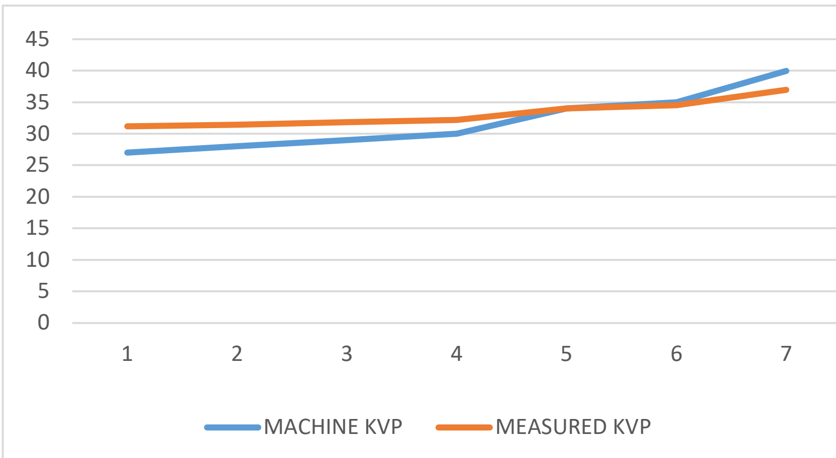

Fig. 2: Relationship Between Measured kVp and Machine (Set) kVp

3. RESULTS AND DISCUSSION

Dose report and exposure factors used for breast x-ray examinations of 112 patients considered in this study were extracted from their respective mammogram, a sample of which is shown in fig.1. The plot of the variation between the set and measured kVp is shown in fig. 2, while their test of significance is presented in Table 1. There was no significance (p=0.05) difference between the set and measured kVp. When breast phantom was exposed using the most frequently selected exposure factors (kVp & mAs), the displayed AGD and measured AGD for different thickness is presented in Table 2. It can be seen from this table that the measured AGD (0.74 mGy) is higher than the displayed (0.41 mGy) by 45%. This variation could be due to difference in the thickness and composition of the glandular tissue (breast granularity) between the actual patient and the phantom.

The summary report of the data (exposure factors, ESE and AGD) of 112 patients extracted from the mammography x-ray storage unit for different projections of the breast namely, Right Craniocaudal (RCC), Left Craniocaudal (LCC), Right Mediolateral Oblique (RMLO) and Left Mediolateral Oblique (LMLO) is presented in Table 3. The overall range of values of AGD (mAs, kVp) received by all these patients from mammography procedure at UCH as displayed on the monitor unit are 1.32 - 1.82 mGy (33 - 47 mAs, 33 - 34 kVp). These values and the ones measured with the breast phantom are within the recommended AGD values of 3 mGy [13]. This agreed with similar study by Joshua et. al. [14], where they used TLD with conversion factors published by Dance to measure AGD and their results were less than 3 mGy. These results showed that the mammogram unit at UCH, Ibadan is well suited for clinical services (breast screening and diagnosis) with minimal radiation dose to patients.

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Table 1: Analysis of the Mammography X-ray Unit Set and Measured kVp

	Mean	N	Standard Deviation	Df	T	p-value
Machine set kVp	**31.8571**	7	**4.670067**	**2.550**	**0.228**	**0.05**
Measured kVp	**33.1571**	7	**2.119636**			

Table 2: Measured and Displayed AGD for Different Phantom (Breast) Thickness

	Set kVp	AGD (Measured) mGy	ESE mGy	mAs	AGD (Displayed) mGy	Thickness mm
	27.0	0.37	1.28	20.0	0.384	61.30
	28.0	0.41	1.35	20.0	0.388	45.50
	29.0	0.48	1.60	20.0	0.396	60.60
	30.0	0.55	1.70	20.0	0.404	45.30
	34.0	0.89	2.46	20.0	0.440	45.40
	35.0	0.99	2.67	20.0	0.460	45.40
	40.0	1.49	3.79	20.0	0.500	45.40
Mean ± SD	**31.9 ± 9.19**	**0.74 ± 0.41**	**2.12 ± 0.91**	**20**	**0.41 ± 0.08**	**49.84 ± 7.59**

Table 3: Summary of Dose Report Extracted Mammography Storage Unit for different X-ray Projection/View

VIEW	ESE (MGY)	AGD (MGY)	MAS	KVP
RCC	4.48±1.54	1.40±0.56	34.31±10.03	33.36±2.22
LCC	4.35±1.51	1.32±0.29	33.08±9.91	33.67±1.63
RMLO	6.54±2.43	1.82±0.93	45.89±15.88	34.0±0.0
LMLO	6.72±2.86	1.77±0.67	46.62±18.99	34.0±0.0

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