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ANALYSIS OF THE UTILIZATION OF THE AUTOMATIC EXPOSURE CONTROL (AEC) FEATURE IN THE USE OF DEEP LEARNING BREAST IMAGE TECHNOLOGY IN WOMEN'S MAMMOGRAM SCREENING EXAMINATIONS AT DHARMAIS CANCER HOSPITAL

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Mammography, Automatic exposure control (AEC), Deep learning

ABSTRACT
Deep learning technology is useful for radiology specialists as double reading to help increase the accuracy of image interpretation results. One of the preparations for maximizing the use of this technology is using good-quality images as the source. The Automatic Exposure Control (AEC) feature, which functions to determine exposure factors automatically, is expected to help produce images with good and consistent quality so that deep learning technology can work more effectively. This research aims to determine the quality results of mammogram images taken using the AEC feature and to analyze the use of deep learning technology in evaluating mammogram images. This research method is retrospective by collecting 800 mammogram images randomly and anonymously. Three hundred images were tested, 500 were evaluated, and 250 were analyzed for image quality based on references related to applying AEC and assessing the contrast-to-noise ratio (CNR). Deep learning technology was analyzed by comparing the results of mammogram image evaluation using deep learning and the evaluation results of a radiology specialist. Deep learning technology analysis shows that 98% of mammograms have the same results as the radiology doctor's evaluation, and 2% have different results from the radiology doctor's evaluation where the image has a dense breast type. The image quality results in this research showed that 97.6% of the 250 samples taken using the AEC feature had good image quality, and 2.4% had poor image quality due to inappropriate breast positioning during the examination.

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INTRODUCTION

A. Background of the problem

Cancer is a disease characterized by several cells that grow uncontrollably and can spread to other body parts (Wedayani & Hidajat, 2022). The World Health Organization (WHO) informs that cancer is the second leading cause of death globally, and based on 2020 Globocan data, the type of cancer with the highest death rate in the world is lung cancer. However, the highest number of new cases occurs in breast cancer (Despitasari & Dila, 2017). Not only in the world, but breast cancer is also cancer with the highest number of new cases in Indonesia, where the number of cases reached 65,858 cases and the number of deaths reached 22,430 cases.

In several types of cancer, healing and survival can be improved by making several efforts, including carrying out screening, early detection, and increasing each individual's awareness of the risk signs and early symptoms of cancer. Several risk factors that need to be known can trigger breast cancer, namely age, family history, reproductive factors, estrogen, and lifestyle (Suardita et al., 2016).

The first factor is related to age; women over 50 years of age are at greater risk of developing breast cancer compared to women under 40 years of age (Sipayung et al., 2022). The second factor is family history. Women whose mothers or older sisters have had a history of breast cancer will be more susceptible to this disease and have a 1.75 times higher risk compared to women whose families have no history of breast cancer (Isnaini & Elpiana, 2018). The third factor is reproductive factors, such as women with late menopause and giving birth to their first child at the age of 30 years and over (Wahyuningsih, 2018). The fourth factor is estrogen or hormonal, such as using oral contraceptives or taking hormonal therapy for a long time. The fifth factor is lifestyle, such as active or passive smoking, alcohol consumption, eating too much fatty food, obesity, and lack of exercise, which will increase the risk of developing breast cancer.

Regarding screening and early detection, the World Health Organization (WHO) and the Ministry of Health of the Republic of Indonesia have recommended that every woman carry out BSE (breast self-examination) and clinical examination by a doctor (Gusti, 2018). If necessary, examination with a mammography device can also be carried out as an initial step in screening and early detection of breast cancer. Breast cancer screening with mammography aims to detect breast cancer at an early stage that can hopefully be cured and to anticipate continuous and linear tumor growth patterns (Abi et al., 2019).

Mammography is a medical examination method that uses low-dose X-rays to obtain images of breast tissue that a radiology specialist can evaluate. This technique is included in non-invasive examinations, so the examination is quite safe, painless, relatively cheap, and has reasonable sensitivity (72-88%). Therefore, up to now, mammography is still the gold standard in supporting medical examinations such as breast cancer screening (Fais, 2020).

The advantage of mammography examination is that it can detect tumors or masses measuring less than 1 cm that cannot be felt when palpated. However, evaluating masses on mammogram images is very difficult because of the differences in shape, size, and margins of different masses, especially in the breast. According to facts in the field, mammography is a medical image that is difficult to evaluate or interpret even by experts. Apart from images that are difficult to evaluate, fatigue, experience, etc., from readers can cause differences in interpretation (Suparmi et al., 2023).

To reduce the risk of errors in interpreting mammogram images and increase the rate of early detection of breast cancer, several medical organizations, such as the American College of Radiology (ACR) and the European Society of Radiology (ESR) have created a program, namely the double reading program. This program is a program that makes mammogram images evaluated by two different radiologists independently. Several countries in Europe and America have implemented this double reading program, but in certain countries, especially Indonesia, following and implementing this double reading program is still very difficult due to the limited number of radiology specialist doctors. The University of Indonesia Medicine informs that the number of radiology specialist doctors in Indonesia currently (2021) is approximately 1,646, serving more than 270 million people. This number still needs to be increased to serve radiology services throughout Indonesia, especially if you add the implementation of the double reading program (Utami & Handayani, 2017).

Therefore, until now, a lot of science and technology continues to be developed to help radiology specialists evaluate and interpret images consistently and accurately. One of these technologies is deep learning, part of artificial intelligence (AI) (Raup et al ., 2022).

Artificial intelligence (AI) is a branch of computer science that aims to build smart devices to perform tasks requiring human intelligence. In its development, artificial intelligence (AI) uses several methods, such as machine learning and deep learning. The deep learning method is a sub-field of machine learning that uses artificial neural networks, which consist of many layers to process data in complex forms. In deep learning, computers require large-scale data sets to increase the system's ability to provide accurate output results. Currently, there are various programs and technologies based on artificial intelligence (A.I.) that have been developed to assist in the interpretation and analysis of mammogram images. One of the A.I. mammography technologies is Transpara, an A.I. program from the Netherlands that works with Dharmais Cancer Hospital, which is being used to test A.I. accuracy on mammogram images.

This technology for radiology specialists can be used as double reading in evaluating images, especially mammograms. This can help radiology specialists increase the accuracy of their interpretation results to reduce the possibility of false negatives or positives (Agustina et al., 2023). increase the confidence of radiology specialists in the results of their interpretation, reduce reading time, and reduce fatigue in interpreting mammogram images because the basis of mammogram images is difficult to interpret.

Getting results from artificial intelligence technology, in particular Deep learning technology that meets expectations and can be relied upon in medical practice, requires several things to be prepared, including a mammogram image with good quality (not underexposed or overexposed). Poor or inadequate imagery can affect the performance and accuracy of A.I. models (Marcheta, 2022).

Good and consistent mammogram image quality can be obtained by utilizing the automatic exposure control feature (AEC). The AEC feature uses an algorithm that can help radiographers determine kV, mAs, targets, and filters automatically based on breast thickness and image needs, thereby producing images with good, optimal, and consistent quality. Generally, image quality assessment using the AEC feature is assessed using the contrast-to-noise ratio (CNR) descriptor.

Apart from getting good and consistent image quality, the use of the automatic exposure control feature (AEC) can also help in reducing unnecessary radiation exposure to patients because although medical imaging using X-rays provides enormous benefits in early detection, there are still concerns about potential side effects such as genetic diseases, cancer, etc. (Lingga, 2013). Patient dose assessment can be determined from the average glandular dose (MGD) as a patient dose descriptor.

Based on the results of research titled Artificial Intelligence for Breast Cancer Detection in Mammography: Experience of Use of the Screenprint Medical Transparent System in 310 Japanese Women (2020), using a retrospective study method on 310 patients, the results showed that A.I. performance lower compared to human readers (Munawir et al., 2023).

Meanwhile, according to research entitled Artificial Intelligence in Medical Imaging of the Breast (2021), by identifying, segmenting, and classifying lesions using AI breast imaging, the results show that AI can reduce pressure on doctors, increase accuracy, and optimize image sources (Sri, n.d.).

Other researchers, in their research entitled Automatic Exposure Control for a Slot Scanning Field Digital Mammography System (2005), revealed that using AEC can reduce image repetition and improve workflow (Ainiyah et al., 2021).

This research has theoretical benefits as a scientific source that can increase readers' insight, especially students of the Department of Radiodiagnostic Engineering and Radiotherapy, regarding the use of artificial intelligence technology. In addition, the practical benefits of this research are expected to provide a useful basis for the application of artificial intelligence in the evaluation and interpretation of mammogram images as well as the use of Automatic Exposure Control (AEC) in producing mammogram images that are of good, optimal and consistent quality.

This study aims to evaluate the quality of mammogram images in screening patients using the automatic exposure control (AEC) feature, measure the average glandular dose (AGD) in breast screening examinations using AEC, analyze the use of AEC as a standard procedure in carrying out breast screening examinations and utilizing deep learning technology as double reading, as well as measuring the accuracy of deep learning technology in the use of AEC on women's mammogram screening images at Dharmais Cancer Hospital.

METHOD

This research uses a retrospective type of research by collecting data from mammogram images taken some time ago, and the data source used is a secondary data source. The population in this study is mammography screening images that have been taken using the Automatic Exposure Control (AEC) feature at Dharmais Cancer Hospital in the 2021 period, totaling 800 images; 300 images are used as test samples and have been taught on normal, benign and malignant images as well as 500 images were used as samples to be evaluated by the Transapara AI program and evaluated for image quality. Sampling will use a systematic random sampling technique. By the recommendations of the American Cancer Society (ACS) and the American College of Radiology (ACR), samples will be taken from patients over 40 years. Images have been taken using the AEC feature. The instrument in this research used an observation sheet—overall research and development activities from March 2023 – June 2023.

RESULTS AND DISCUSSION

General description of the research site

A Brief History of Dharmais Cancer Hospital

Dharmais Cancer Hospital was founded in May 1991, and construction was completed on July 5, 1993. President HM Soeharto inaugurated this hospital on October 30, 1993. He hoped that this hospital could significantly contribute to efforts to prevent and cure cancer, accompanied by a valuable research center and reliable medical service center that would support cancer control programs. This is also by the duties and functions stated in Minister of Health Decree No.72/Menkes/SK/I/1993 concerning the organization and work procedures of RSKD, which has established installations that operate in service, education, and research. (Kristianawati et al., 2018) .

Then, in 2022, considering the vision that has been set that in the future, RSKD will become a Cancer Hospital and National Cancer Center which will become a role model in cancer control programs in Indonesia, the RSKD Main Director Decree No HK.00.06.1.1812 concerning the formation of a central preparatory committee RSKD national cancer is tasked with conducting an assessment of the position, authority, functions and duties of the national cancer center, then developing the concept of a cancer center and carrying out cancer research, training and cancer registration (Usman, nd).

In 2008, a review and redefinition of the role of the Dharmais Cancer Hospital (RSKD) was carried out as part of the National Cancer Center, where it was hoped that this institution could contribute to the implementation of a real national cancer control program by supporting the program launched by the Ministry of Health and finally the date November 1 2017, Dharmais Cancer Hospital Jakarta was designated as a national cancer center based on R.I. No.HK.01.07/Menkes/531/2017 (Usman, nd).

Hospital medical rehabilitation, education and research installations, cancer burden data installations and networks, and all other installations that support the smooth running of activities in the fields of services, education, and research in the field of cancer (epidemiology, clinical, molecular, clinical trials).

By the referral system currently in effect in Indonesia, RSKD is a national referral. It is increasingly necessary to evaluate and find the best work plan to treat patients at any stage or who have experienced delays, whether diagnostic delays, treatment delays, or delays due to the health management system. Educational collaboration and the return referral system, as well as the synchronization of clinical practice guidelines with community health centers and type C, D, and B hospitals, need to be improved (Marwayani, 2021).

Vision and Mission of Dharmais Cancer Hospital

As a Vertical UPT Hospital under the Directorate General of Health Services, Ministry of Health, which specializes in treating cancer, Dharmais Cancer Hospital plays a role in realizing strategic targets related to increasing the availability and quality of referral health facilities. Apart from that, Dharmais Cancer Hospital is also a National Cancer Center, which must play an optimal role as a comprehensive cancer health service function, a national cancer education and information center, and a national cancer data and research center (Panigoro, 2014).

Types of services at Dharmais Cancer Hospital

The types of services available at Dharmais Cancer Hospital are medical and nursing services. Dharmais Cancer Hospital has superior services such as an integrated laboratory, stem cell transplantation, minimally invasive surgery, microsurgery, super microsurgery, lymphatic venous surgery, ultra-radical surgery, cancer wound care, palliative, cancer pain management, and complementary therapy. Apart from that, RSK Dharmais also has early cancer detection services, systemic therapy installations, etc.

Early cancer detection services

The types of early cancer detection services provided by Dharmais Cancer Hospital are:

a. Early detection of breast cancer: Mammography (age > 40 years), breast ultrasound (age < 40 years).
b. Early detection of cervical cancer: Pap smear, HR-HPV, Quadrivalent HPV Vaccination.
c. Early detection of colon cancer: Occult blood, M2PK, CEA.
d. Early detection of thyroid cancer: thyroid ultrasound, lab, total T3, FT4, TSH.
e. Early detection of prostate cancer: Prostate Ultrasound, PSA Lab, etc.
f. Early detection of liver cancer: upper abdominal ultrasound, Lab, AFP, HBSAG, Anti HSB, Anti HCV.
g. Early detection of ovarian cancer: Gynecological Ultrasound, Ca 125 Lab.
h. Early detection of lung cancer: MSCT Scan Thorax, Ureum, Creatinine.

Descriptive analysis of the sample

The number of samples used and evaluated in this study was 200 patients. It is known that the lowest age in this study was 36 years, and the highest was 77 years, as shown in Table 1.

Table 1 Number and age of the sample

Number of patients	500 people
Lowest patient age	36 years old
Highest patient age	77 years old

The minimum age for women at risk of breast cancer recommended by the American Cancer Society (ACS) and the American College of Radiology (ACR) to undergo breast screening examinations using mammography is a minimum age of 40 years. From the data in Table 2, it is known that two samples did not comply with the recommendations or 0.4% of the total sample.

Table 2 Sample age range

Age	Amount	Percentage
<40 Years	2	0.4%
40 – 50 Years	226	45.2%
51 – 60 Years	209	41.8%
61 – 70 Years	55	11%
>70 Years	8	1.6%
Total	500	100%

Analysis of image quality results using SdNR and PMMA thickness

The image quality of all mammogram samples totaling 200 images has been evaluated by creating 3 Regions of Interest (ROI), each ± 1 wide cm^2 in the breast area and 1 ROI in the object-free area as in Figure 1, then the average ROI results. Calculated using the Signal difference to Noise Ratio (SdNR) formula, equivalent to Contrast to noise ratio (CNR).

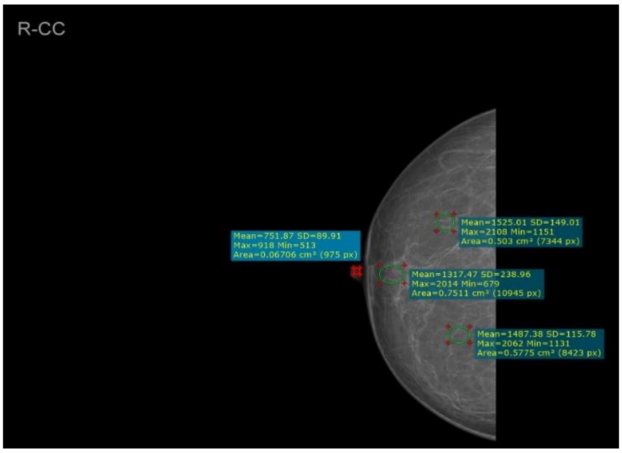


Figure 1 ROI of mammography image in RCC projection

After the Signal difference to Noise Ratio (SdNR) was evaluated by looking at or comparing it with the SdNR reference value in mammography proposed by the IAEA, it was found that there were 5 (2.4%) mammography images that were of poor quality and 195 (97.6%) mammography images that were of poor quality. Good image, as shown in Table 3.

Table 3 Analysis of mammogram image quality results

Image quality	Total image	Percentage
Not good	6	2.4%
Good	244	97.6%
Total	250	100%

Suppose the image quality is seen based on the thickness of the breast. In that case, it is known that poor image quality occurs mostly in thin breasts in the amount of 5 (2%) images and 1 (0.4%) image in standard breasts.

Table 4 Cross-tabulation of breast thickness and image quality

Breast girth	Image quality		Total
	Not good	Good	
Thin (<53mm)	5 (2.0%)	129 (51.6%)	134(53.6%)
Standard (53-90mm)	1 (0.4%)	115 (46.0%)	116(46.4%)
Total	5 (2.4%)	195 (97.6%)	250

Analysis of the mean glandular dose of mammography screening patients

Information on the average glandular dose in each mammography image can be seen in the DICOM tag of each image or the text image, as shown in Figure 2 below.

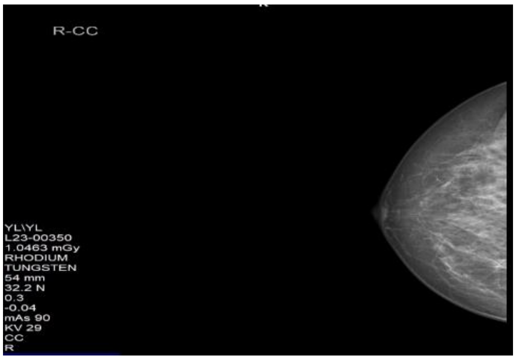


Figure 2 Example of an RCC projection mammogram image

One of the mammogram image samples in the Right Cranio-Caudal (RCC) projection above shows that the average dose is 1.0463 mGy.

The results of the evaluation of 250 samples of female patients with mammography screening showed that 250 or all patients in this study received an average glandular dose of less than three mGy, as shown in Table 5.

Table 5 Analysis of the average patient glandular dose

Patient dosage	Amount	Percentage
<3mGy	250	100%
≥3mGy	-	0%

This shows that each patient received a radiation dose by the recommendations of the Indonesian Nuclear Regulatory Agency, namely less than 3mGy.

Of the 250 samples that have been evaluated, it is known that the average glandular dose is 0.9151 mGy, with the lowest glandular dose being 0.31 mGy and the highest glandular dose being 1.97 mGy, as shown in Table 6.

Table 6 Average patient glandular dose

Average glandular dose of samples	mGy
Average (mean)	0.9179
Minimum	0.31
Maximum	2.19

Cross-tabulation analysis of deep learning technology results and radiology specialist reading results

The results of the cross-tabulation analysis of mammogram image evaluation results using deep learning technology and the reading evaluation results of radiology specialist doctors can be seen in Table 7. Table 7 shows that there are three images (0.6%) that have high A.I. results. The doctor's reading results are normal; 66 images (13.2%) had intermediate A.I. results and normal doctor reading results, 340 images (68%) had low A.I. results and normal doctor reading results, two images (0.4%) had high A.I. results and benign radiology doctor reading results, 29 images (0.5%) %) had intermediate A.I. results and benign radiology results, 49 images (9.8%) had low A.I. results and benign radiology results, four images (0.8%) had high A.I. results and malignant radiology results, four images (0.8%) had intermediate A.I. results and malignant radiology results, and three images (0.6%) had low A.I. results and malignant radiology results.

Table 7 Cross-tabulation analysis of A.I. results and doctor reading results

Results of deep learning (A.I.) technology	Doctor's reading results			Total
	Normal	Benign	malignant	
Tall	3 (0.6%)	2 (0.4%)	4 (0.8%)	9
(high risk of malignancy)	BI-RADS 1	BI-RADS 3	BI-RADS 5	
Intermediate	66 (13.2%)	29 (0.5%)	4 (0.8%)	99
(benign)	BI-RADS 2	BI-RADS 3	BI-RADS 4	
Low	340 (68%)	49 (9.8%)	3 (0.6%)	392
(low/normal risk)	BI-RADS 1	BI-RADS 3	BI-RADS 4	
Total	409	80	11	500

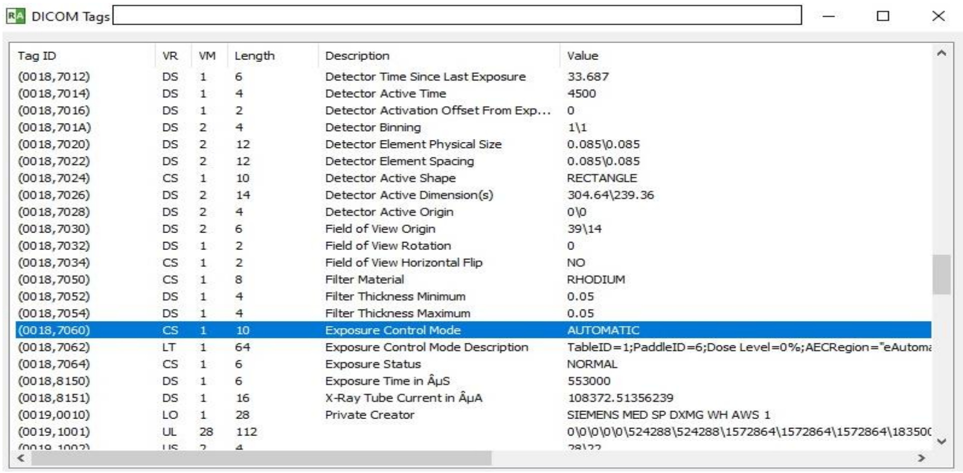
Referring to Table 8 regarding the six categories of BI-RADS (Breast et al.), which is an initial assessment and recommendation system used to report mammography results, it is known that there are 343 images included in BI-RADS category 1, 66 images included in category BI-RADS 2, 80 images including BI-RADS 3, 7 images including BI-RADS 4, and 4 images including BI-RADS 5 which in BI-RADS 4 and BI-RADS 5 require further action such as a biopsy to confirm whether the lesion is those found to be malignant or benign. A biopsy can help in identifying the type of breast cancer and determining an appropriate treatment plan (7).

Breast Imaging reporting and data system) categories

Category 0	Requires additional evaluation such as follow-up examination or ultrasound,
Category 1	Negative mammography: No abnormalities are seen on mammography
Category 2	Benign findings. An obvious abnormality was found, but it is most likely not cancer or another malignant abnormality. No further action is required.
Category 3	Disorders that may be benign. An abnormality is found that is likely benign but requires future monitoring with mammography to ensure there are no changes.
Category 4	Possibly malignant. A suspicious abnormality was found, but it has not been determined to be malignant. Usually, follow-up procedures such as a biopsy are carried out.
Category 5	She is suspected of being malignant. Abnormalities highly suspicious for cancer were found. A biopsy is usually recommended for confirmation.
Category 6	Confirmed cancer.

Analysis of the use of Automatic Exposure Control (AEC)

Information on using the Automatic Exposure Control (AEC) feature on an image can be seen in the DICOM tags of each image, as shown in Figure 24.


DICOM Tags

Tag ID	VR	VM	Length	Description	Value
(0018,7012)	DS	1	6	Detector Time Since Last Exposure	33.687
(0018,7014)	DS	1	4	Detector Active Time	4500
(0018,7016)	DS	1	2	Detector Activation Offset From Exp...	0
(0018,701A)	DS	2	4	Detector Binning	1\1
(0018,7020)	DS	2	12	Detector Element Physical Size	0.085\0.085
(0018,7022)	DS	2	12	Detector Element Spacing	0.085\0.085
(0018,7024)	CS	1	10	Detector Active Shape	RECTANGLE
(0018,7026)	DS	2	14	Detector Active Dimension(s)	304.64\239.36
(0018,7028)	DS	2	4	Detector Active Origin	0\0
(0018,7030)	DS	2	6	Field of View Origin	39\14
(0018,7032)	DS	1	2	Field of View Rotation	0
(0018,7034)	CS	1	2	Field of View Horizontal Flip	NO
(0018,7050)	CS	1	8	Filter Material	RHODIUM
(0018,7052)	DS	1	4	Filter Thickness Minimum	0.05
(0018,7054)	DS	1	4	Filter Thickness Maximum	0.05
(0018,7060)	CS	1	10	Exposure Control Mode	AUTOMATIC
(0018,7062)	LT	1	64	Exposure Control Mode Description	TableID=1;PaddleID=6;Dose Level=0%;AECRegion="eAutom
(0018,7064)	CS	1	6	Exposure Status	NORMAL
(0018,8150)	DS	1	6	Exposure Time in ÂµS	553000
(0018,8151)	DS	1	16	X-Ray Tube Current in ÂµA	108372.51356239
(0019,0010)	LO	1	28	Private Creator	SIEMENS MED SP DXMG WH AWS 1
(0019,1001)	UL	28	112		0\0\0\0\0\524288\524288\1572864\1572864\1572864\18350

Figure 3 Example of DICOM tags on one of the mammogram images

The results of the evaluation of all samples or images show that all 250 images in this study were taken using the Automatic Exposure Control (AEC) feature.

Table 9 Number of images using AEC

Automatic Exposure Control	Amount	Percentage
Using AEC	250	100%
Do not use AEC	-	-
Total	250	100%

With the Mammomat inspiration type mammography device used at the Dharmais Cancer Hospital, the parameters automatically set by the system are kV and mAs, while the filter is selected manually.

CONCLUSION

Based on research that has been carried out on mammography images of breast screening patients at Dharmais Cancer Hospital, the following conclusions can be drawn: The use of the automatic exposure control (AEC) feature can help improve image quality during mammography examinations. In this study, 97.6% of the images had good image quality. The automatic exposure control (AEC) feature can provide an optimal and safe patient radiation dose below 3mGy by recommendations from the Nuclear Energy Regulatory Agency. In this study, the smallest average glandular dose was 0.3mGy, and the highest was 2.19mGy. The automatic exposure control (AEC) feature can be used as a standard protocol in breast screening examinations because the AEC feature can set exposure parameters such as kV, mA, and exposure time automatically based on the density of each patient's breast tissue so that it can produce good image quality with optimal and safe radiation dose.

The consistency of mammogram image quality results produced using the automatic exposure control (AEC) feature can help evaluate the use of artificial intelligence (A.I.) because A.I. will be more effective in studying the patterns and characteristics of lesions on mammograms. In this research, the accuracy of using artificial intelligence technology with deep learning methods was 98%. Currently, deep learning technology in evaluating dense breast images still has difficulties or challenges because dense breast tissue has a complex structure, making it difficult for A.I. to differentiate between dense and non-dense tissue. This can affect the detection of lesions on mammogram images.

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