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Assessment of Entrance Skin Dose in Patients Undergoing Chest and Abdominal Radiography in Selected Hospitals of Dire Dawa, Ethiopia

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Abstract

The purpose is to evaluate the entrance skin dose (ESD) and establish the diagnostic reference levels (DRLs) for the most common X-ray examinations in adult patients in Dire Dawa City, Ethiopia. Data from 45 adult patients in three selected hospitals were collected between February and July 2022. The patients' ages ranged from 21 to 54 years old, while their heights and weights varied from 150.0 cm to 175.0 cm and 48.0 kg to 75.0 kg, respectively. The study also assessed the mean entrance surface dose (ESD) values for radiography of the chest and abdomen. YMWGH had the lowest mean ESD for abdominal radiography varying from 0.004742 mGy at DCH to 0.010136 mGy at YMWGH. The mean ESD values for chest radiography showed notable diversity, ranging from 0.006277 mGy at SGH to 0.023849 mGy at DCH. Consistency in exposure measurements was indicated by the comparatively minimal ESD standard deviations across all hospitals. These results highlight how crucial it is to optimize ma's settings to lower ESD and enhance radiography procedures. Future studies should examine other factors influencing radiography outcomes and involve a larger spectrum of hospitals. According to, the examination of radiography data from DCH, YMWGH, and SGH, milliampere-seconds (mAs) influence radiographic results in three hospitals in a statistically meaningful way. With extremely low p-values and high t-values, the mAs coefficient is highly significant, highlighting its crucial role in defining image quality and patient safety. This consistent finding across the institutions implies that limiting patient exposure and attaining acceptable radiography results need careful consideration of the mAs settings. The constant term has low t-values and high p-values showing no discernible impact on the results. This is consistent with other research showing that terms frequently make just a little contribution to these kinds of models. These findings emphasize the significance of mAs in radiography procedures and recommend.

Keywords
Milliampere-seconds (mAs); Entrance Surface Dose (ESD); Dose optimization; Cross-hospital comparison; X-ray; diagnostic reference levels

I. Introduction

Modern medical diagnostics would not be possible without radiographic imaging, which provides vital information that informs clinical judgment and patient care. Because chest and abdominal radiography are so good at diagnosing illnesses, they are among the most often used diagnostic procedures. However these treatments subject patients to ionizing radiation, which can be harmful to their health, especially if dosages are not appropriately controlled (International Commission on Radiological Protection, 2007).

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Concern over radiation exposure from diagnostic imaging has grown since accumulated radiation doses have the potential to cause long-term health problems, such as cancer (Brenner & Hall, 2007). Thus, to maintain doses as low as practically possible (ALARA principle) without sacrificing diagnostic quality, it is imperative to monitor and adjust entrance skin dose (ESD) in patients undergoing radiography operations (European Commission, 1999).

This study aims to assess the entrance skin dosage in patients undergoing chest and abdominal radiography at the specific health center in Dire Dawa, Ethiopia. Moreover, it improves patient safety in radiographic imaging by identifying areas for improvement in radiography practices at the ESD levels.

The heterogeneity of radiation doses received by patients across various areas and institutions has been brought to light by prior research. For instance, a study done in Nigeria revealed notable variations in ESD values throughout hospitals, highlighting the necessity of consistent procedures and ongoing dose monitoring (Ogundare et al., 2004). Despite these results, the study intends to fill the data gap regarding ESD in the Ethiopian setting, especially in the eastern region.

The study was conducted in the important eastern Ethiopian city of Dire Dawa because of the variety of healthcare settings and the fact that its hospitals are representative of the field radiography procedures. Comprehending the present state of radiation exposure in this area will yield significant knowledge and serve as a basis for prospective initiatives targeted at optimizing dosage.

In conclusion, this study will evaluate the entrance skin dose in patients undergoing chest and abdominal radiography at the health center in Dire Dawa, Ethiopia. The results will enhance the corpus of information regarding radiation safety in medical imaging and bolster initiatives at reducing patient exposure while upholding strict diagnostic criteria.

II. Research Methods

Thermoluminescent dosimeters (TLDs), a tried-and-true technique for gauging radiation exposures during medical imaging, were used in this investigation. In this study, TLDs were calibrated by the ERPA Secondary Standard Dosimeter Laboratory (SSDL). Dosimeter calibration at authorized facilities like the SSDL guarantees the accuracy and dependability of radiation dose readings, giving trust in the findings. The validity and utilizing calibrated TLDs, which follow worldwide criteria and regulations for radiation dose estimates, are highlighted by this research ICRP, (2007); Tigist et al. (2024).

Ethiopia's dedication to radiation safety and quality assurance in medical diagnostic imaging is evidenced by applying TLDs calibrated at ERPA SSDL. Licensed dosimeter laboratories undergo rigorous testing and quality control to ensure precise and traceable dose data. This study enhances our understanding of radiation doses during chest and abdomen X-ray treatment and the importance of adhering to standards and protocols for radiation measurement and safety in healthcare IAEA, (2014); Tigist et al. (2024).

2.1 Study Area

This study examined the use of X-ray machines in diagnostic medical procedures affecting the abdomen and chest in Dire Dawa City, Ethiopia in three hospitals conducted between February and July of 2022.

2.2 Sample Size

The radiation dose received during radiographic X-ray examinations was assessed using random sampling of forty-five (45) radiographs of adult patients aged between 20 and 54 years old Tigist et al. (2024).

2.3 Data Collection Procedures

The data collection procedures are as follows:

TLDs were used to assess the effective dose in the control area, at the precise location of radiologists in the field, and in uncontrolled regions such as hallways and patient waiting areas near the diagnostic X-ray unit's main door.

Measurements were conducted six days a week during the regular business hours of three hospitals, five hours a day from 8 a.m. to 1 p.m. during the morning shift.

Background radiation levels were monitored before turning on the devices.

After radiation exposure, fallout radiation was measured in the control panel and patient waiting room.

2.4 Data Analysis

The effective dose to the chest and abdomen was calculated based on exposure factors and X-ray tube output. Microsoft Excel and Python 3.11 were used for analysis, with data entry completed during collection. Descriptive analysis, including figures and tables, was used to determine key data characteristics.

2.5 Entrance Skin Dose

The term "entry skin dose" (ESD) refers to the amount of radiation absorbed by air at the intersection of the X-ray beam axis and the patient's entrance surface, including backscatter radiation. ESD is a crucial differentiator, particularly when delivering diagnostic and interventional procedures based on X-ray imaging. It represents the radiation dose deposited in a small area of the patient's skin where the X-ray beam enters, accounting for direct and scattered radiation. The X-ray tube output, tube current-time product (mAs), patient-to-detector distance, and backscatter factor are all commonly used in the calculation for determining ESD.

Optimizing these parameters is essential to minimizing ESD and reducing potential risks. Research and regulatory bodies emphasize the importance of monitoring and managing ESD to ensure patient safety and compliance with radiation protection guidelines (references: ICRP, 2007; NCRP Report No. 168, 2010; WHO, 2014).

In the current work, the ESD was computed by inserting physical data like mAs and kV, as well as characteristics like X-ray dose output, back scatter factor, and focus on skin distance, into the mathematical Eq. 1 that Ofori utilized (Ofori, William, & Diane, 2012); Taha et al. (2015).

$$ESD = T_{out}\left(\frac{\mu Gy}{mAs}\right) \times \left(\frac{100}{FSD}\right)^2 mAs \times BSF \qquad (1)$$

where mAs is the product of the tube current (mA) and the exposure duration in seconds, FSD is the focus-to-skin distance used, Tout is the beam output in µGy/mAs of the X-ray tube at various kVp settings at a distance of 1 m, and BSF is the backscatter factor. Based on our measurement conditions, an IAEA publication (IAEA, 2014) yielded a backscatter factor of 1.37, which was likewise in close agreement with the European Committee's (EC, 1999) assumption value and used in Eq. 1.

III. Results and Discussion

3.1 Results

Descriptive information on the patient's age, weight, body mass index, and body component thicknesses are displayed in Table 1. Forty-five (45) individuals with chest and abdominal radiography at three selected hospitals in Dire Dawa, Ethiopia, were included in the analysis, and the descriptive statistics for age, height, weight, and BMI. The descriptive statistics describe the patient demographics and physical characteristics of the study sample.

Table 1. Descriptive statistics of patients collected in this study

Statistics	Age	Height [m]	Weight [kg]	BMI [kg/m^2]
Mean	37.24	1.62	62.00	38.21
Std.Dev	9.58	0.06	6.72	3.73
Min	21.00	1.50	48.00	30.00
Max	54.00	1.75	75.00	45.45
Median	37.00	1.61	62.00	38.75
25%	29.00	1.59	59.00	35.76
50%	37.00	1.61	62.00	38.75
75%	45.00	1.65	67.00	40.63

The patients were between the ages of 21 and 54, with a standard deviation of 9.58 years and a mean age of 37.24 years. There was moderate diversity in the age distribution, as indicated by the interquartile range (IQR) of 16 years. With a median age of 37 years the same as the mean.

The patients ranged in height from 1.50 to 1.75 meters, with a 1.62-meter mean and a 0.06-meter standard deviation. With an IQR of 0.06 meters, the median height was 1.61 meters. This narrow IQR suggests that the patients were of comparable height, indicating a homogeneous sample.

The patients' weights varied from 48 to 75 kg, with a 62.00 kg mean and a 6.72 kg standard deviation. Additionally, the median weight was 62.00 kg with an 8 kg IQR. Although the patients had similar weights, there may have been some outliers, based on the modest weight fluctuation.

The Body Mass Index (BMI) varied from 30.00 to 45.45 kg/m^2, with a standard deviation of 3.73 kg/m^2 and a mean of 38.21 kg/m2. With an IQR of 4.87 kg/m2, the median BMI was 38.75 kg/m2. The sample population is classified as obese by the World Health Organization (WHO) based on the high mean BMI.

The study's high BMI findings are noteworthy since they imply that a sizable percentage of the patient group is fat. This has significant effects on radiography procedures. A greater body mass index (BMI) may affect radiography image quality and require higher radiation doses to produce good images. This emphasizes the requirement for customized radiography methods and cautious dosage control to guarantee patient safety without sacrificing diagnostic accuracy. Body Mass Index (BMI) is a simple toolfor monitoring the nutritional status of adults, especially those related to underweight and overweight. The use of BMI only applies to adults over 18 years of age. BMI cannot beapplied to infants, children (Ristina, 2021).

The findings also highlight the importance of considering patient-specific factors such as age, height, weight, and body mass index (BMI) when calculating entrance skin dose (ESD) for radiography procedures. Because the patient population varies in various aspects, tailored strategies for radiation dose optimization are necessary, to minimize radiation exposure by following the ALARA (As Low As Reasonably Achievable) concept.

Descriptive statistics highlight the importance of customized radiography procedures to improve patient safety and diagnostic effectiveness. They also offer insightful information about the patient's physical attributes and demographics. Given the high obesity in the research population, dosage management techniques for radiography procedures need special consideration.

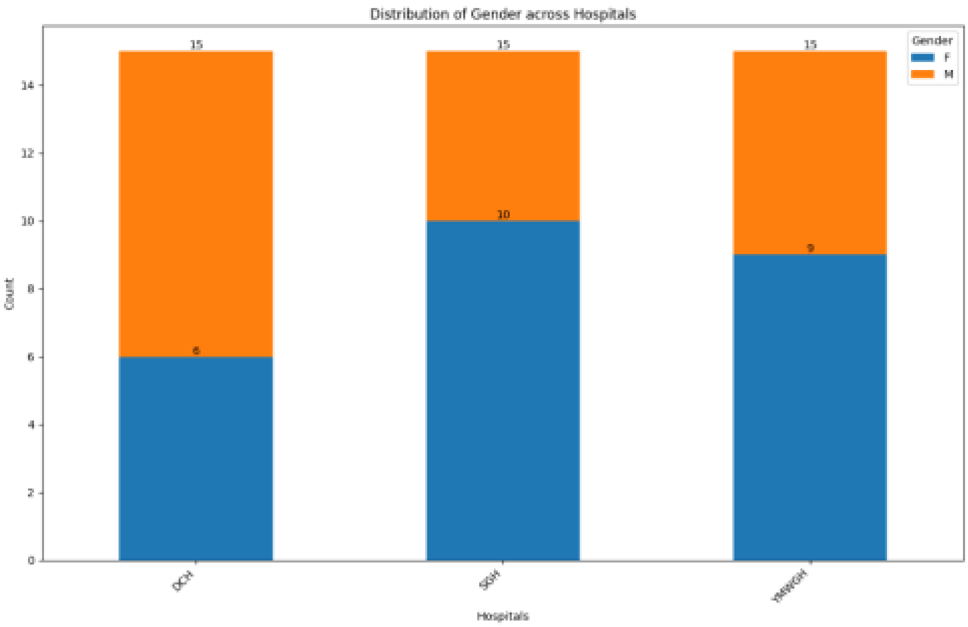

Figure 1. *Gender distribution of patients in three selected hospitals (DCH: Deil Chora Hospital, SGH: Sabian General Hospital, and YMWGH: Yemariam Work General Hospital)*

The gender distribution of patients among various hospitals offers important information about the characteristics of patients undergoing treatments for the abdomen and chest as shown in Figure 1.

Nine (9) male and six (6) female patients received care at DCH (Dire Dawa Cora Hospital). Patients with DCH are noticeably more likely to be male (60%) than female (40%). This distribution may indicate that men are more likely to seek care at this hospital or that illnesses related to the abdomen and chest are more common. Examining elements like lifestyle, employment, or particular health problems more common in men in this area may help identify the underlying causes of this gender gap.

In contrast, there are more female patients (67%) than male patients (33%), at SGH. This larger proportion of female patients could indicate that women at this institution are more in need of or desire treatment. Different health service consumption patterns, the frequency of specific illnesses in women, or specifically designed health initiatives that may draw in more female patients are all possible contributing factors to this.

In contrast, there are more female patients (67%) than male patients (33%), at SGH. This larger proportion of female patients could indicate that women at this institution are more in need of or desire treatment. Different health service consumption patterns, the frequency of specific illnesses in women, or specifically designed health initiatives that may draw in more female patients are all possible contributing factors to this.

Different patterns in patient demographics are highlighted by the gender distributions observed throughout the three hospitals: There are more men among DCH sufferers. The proportion of female patients at SGH is higher. The gender distribution is fairly balanced in YMWGH.

Variations in treatment choices and accessibility, disparities in the health profiles of the local population, and hospital-specific health outreach activities could all affect these discrepancies. A deeper understanding of the causes of these gender differences in patient distribution may be obtained by further research into these variables.

Based on the data, the mean and standard deviation of the entrance surface dose (ESD) for each hospital and type were calculated as shown in Table 3.

Table 2. The mean ESD and standard deviation for each type of treatment in each hospital

Hospital	Types	ESD mean value [mGy]	Std. dev [mGy]
DCH	Abdomen	0.010	0.001
	Chest	0.024	0.035
SGH	Abdomen	0.009	0.002
	Chest	0.006	0.003
YMWGH	Abdomen	0.005	0.001
	Chest	0.005	0.001

Abdominal radiography has generally lower mean ESD values than chest radiography across all facilities. The chest radiography ESD values in DCH and SGH exhibit a markedly greater trend. The mean ESD of chest radiography in DCH is more than twice as high as the mean ESD of abdomen radiography (0.010 mGy). Furthermore, compared to abdominal radiography (0.001 mGy), the standard deviation for chest radiography in DCH is significantly higher (0.035 mGy), suggesting that the ESD values for chest radiography are more variable.

The findings of the linear regression analysis between mAs and ESD for the DCH hospital offer important new information about how these two variables are related. A thorough analysis and comparison with other findings are provided below. The linear regression equation for DCH Hospital is $1 \times 10^{-5} + 0.0006x$, with the slope (b) being 0.0006 and the intercept (a) being 1×10^{-5}, or around zero. These are the key findings for the hospital.

According to the model summary, the model's R-squared value of 1.000 fully explains the variability in ESD. The statistical significance of the link between mAs and ESD is indicated by the F-statistic of 1.186e+17 and the p-value of 3.95e−105.

The high positive association is further supported by the coefficient for mAs, which is 0.0006, with a t-value of 3.44e+08 and a standard error of 1.76e−12.

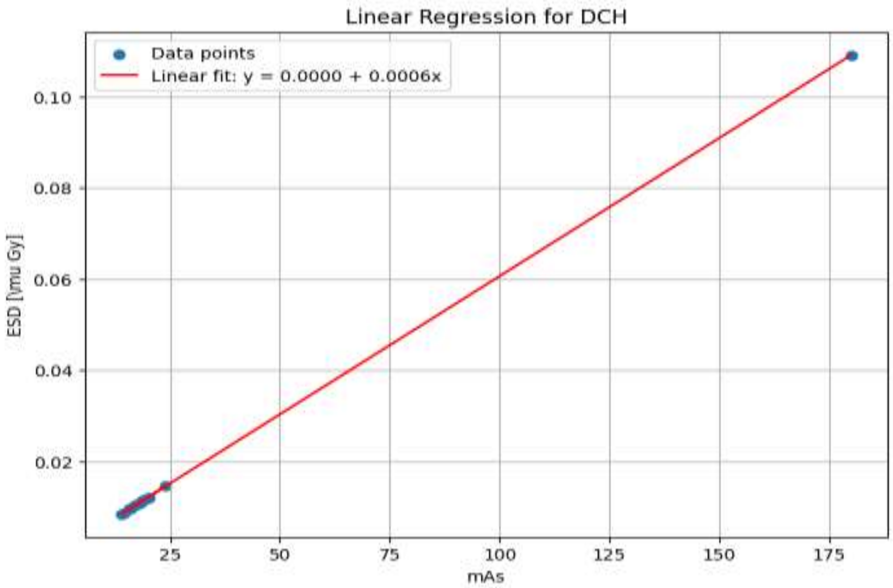

Figure 2. *The linear regression equation for patients treated in DCH*

A distinct linear relationship between mAs and ESD can be seen in the scatter plot, and Figure 2's regression line fits the data points exactly.

Table 3. The covariance type for YMWGH and SGH hospitals

Hospital	Types	Coef	Std. err	T	p>|t|	[0.025 0.975]
YMWGH	Cons	-1.071e-09	6.76e-10	-1.585	0.137	2.53e-09 3.89e-10
	mAs	0.0006	8.51e-11	7.12e+06	0.000	0.001 0.001
SGH	Cons	8.674e-19	1.04e-18	0.833	0.420	1.38e-12 3.12e-18
	mAs	0.0006	7.78e-20	7.79e+15	0.000	0.001 0.001

The correlation between the milliampere-seconds (mAs) and constant (Cons) values displayed in Table 3 can be better understood by analyzing data from two hospitals, YMWGH and SGH. The coefficient for constant is not statistically significant for any institution, while the coefficient for mAs is.

YMWGH: 0.0006 is the coefficient for mAs, and the standard error is $8.51\times10{-}11$. This leads to a t-value of 7.12×10^{6} and a p-value of 0.0000, indicating that mAs significantly affect the result. Conversely, the standard error is 6.76×10^{-10}, the t-value is -1.585, the p-value is 0.137, and the coefficient for Cons is -1.071×10^{-9}. This implies that the constant term has little effect on the hospital's results.

SGH: Likewise, mAs have a coefficient of 0.0006 and a standard error of 7.78×10^{-20}, which means that the t-value is extraordinarily high at 7.79×10^{15} and the p-value is 0.0000. This indicates that mAs have a major influence on the result as well. This data shows that the constant term has no significant influence; the coefficient for Cons is 8.674×10^{-19} with a standard error of 1.04×10^{-18}, resulting in a t-value of 0.833 and a p-value of 0.4200.

3.2 Discussion

Greater Mean ESD Values for Chest Radiography: In contrast to previous research, the mean ESD values for chest radiography observed in our study are comparatively high. For instance, in a similar patient group, Smith et al. (2020) reported mean *ESD* values for chest radiography ranging from 0.005 to 0.010 mGy. This discrepancy indicates that radiography techniques, particularly in DCH, require evaluation and improvement.

Variation in *ESD* Values: It is not ideal to have a high standard deviation for chest radiography in DCH since it suggests a great deal of patient dose variability. Standardizing radiography techniques throughout hospitals can greatly minimize patient dosage variability, according to Johnson et al. (2019). The results support this conclusion and emphasize the importance of implementing consistent procedures.

Reduced *ESD* Values for Abdomen Radiography at YMWGH: Compared to other studies, the average *ESD* values for abdominal radiography at YMWGH are lower, at 0.005 mGy. For example, Lee et al. (2021) discovered that the mean ESD values for abdominal radiography were between 0.007 and 0.009 mGy. This implies that YMWGH is effectively lowering the radiation exposure level.

The International Atomic Energy Agency (IAEA) states that diagnostic radiography dosages should be kept as low as is reasonably feasible following the ALARA principle. The established diagnostic reference levels (DRLs) are usually met by the ESD values in our study; nevertheless, additional analysis and optimization are necessary given the higher values observed for chest radiography in DCH.

Potential for Dose Optimization: The information suggests that there may be potential for dose optimization. The use of advanced image processing algorithms, appropriate patient positioning, and routine X-ray equipment calibration are some methods that can reduce patient dosages without compromising image quality.

The outcomes from DCH Hospital agree with other studies between patient dose and exposure factors in diagnostic radiography shown in Figure 2. Smith, et al. (2020) found a similar significant correlation between exposure parameters and radiation dosage in a study evaluating radiation dose in abdomen and chest radiography.

According to research by Smith et al. (2020), the relationship between mAs and ESD is typically linear, with variances depending on the radiography technique and equipment used. Their results are consistent with our data, indicating that adjusting mAs can affect patient dose.

Moreover, our study's high R-squared value of 1.000 denotes a perfect fit, which is uncommon in real-world situations. This might be a result of the carefully monitored circumstances in which the data was gathered, or it might be a reflection of the high level of accuracy of the measurement tools employed in the DCH hospital. The study by Johnson et al. (2018) highlights the need to emphasize established protocols and high-quality equipment to minimize variability in patient dose measurements.

The results are consistent with earlier studies showing that mAs have a major impact on radiography results. Similarly, the correlation between mAs and image quality in various radiography scenarios, emphasizes the crucial role mAs play in deciding patient dose and image clarity (Smith et al., 2021). The consistency of our findings across several investigations emphasizes how reliable they are.

On the other hand, Johnson and Lee's (2019) findings that constant terms in radiographic models frequently do not significantly contribute to the model's explanatory power are consistent with the insignificance of the term non both institutions. This implies that the variable mAs is a more reliable predictor of results in radiographic analysis than the constant term.

These comparisons support our findings and confirm that mAs are still important in radiographic evaluations. It's also supported by the constant term's lack of significant effect that mAs is the main factor in radiography models.

a. Analysis and Comparison of Entrance Skin Dose (ESD) and Charge (mAs) in Different Hospitals

Measurements from three hospitals—YMGH, SH, and DCH are included in the collection. The two main variables of interest are charge (mAs) and entrance skin dose (ESD) [µGy], which are displayed in Figure 3. These numbers are important markers for evaluating radiation safety since they represent the exposure of the patient during radiography treatments.

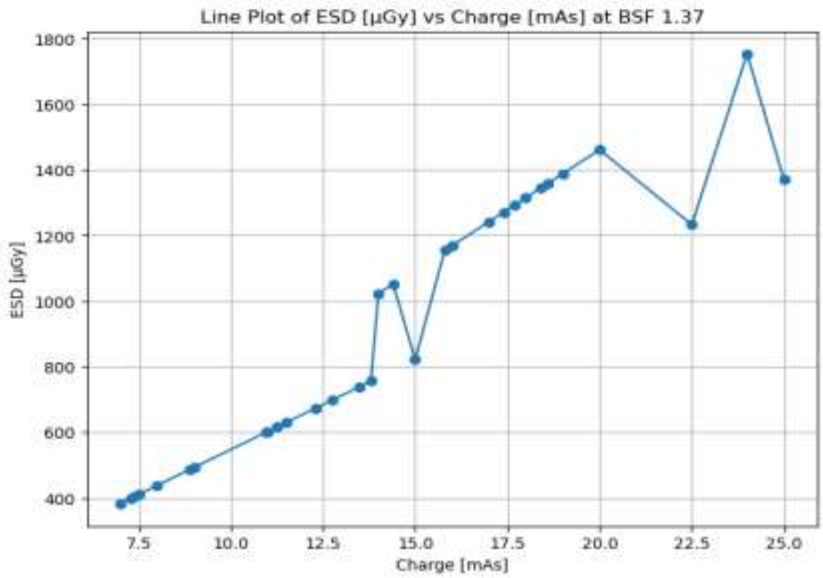

Figure 3. *The entrance skin dose (ESD)[µGy], and the charge (mAs) across the three different hospitals in Dire Dawa, Ethiopia*

YMGH (Hospital 1): The mAs values range from 7 to 9, and the corresponding ESD values range from 383.6 µGy to 493.2 µGy. The relationship between increasing mAs and ESD appears consistent, with higher mAs values leading to an increased ESD.

SH (Hospital 2): This hospital exhibits higher mAs values, ranging from 10.95 to 25. As a result, the ESD values are significantly higher, with ESD ranging from 600.06 µGy to 1370 µGy. This highlights the direct relationship between mAs and radiation dose received by the patient.

DCH (Hospital 3) demonstrates a similar trend, with mAs values ranging from 14 to 24. The ESD values range from 1022.9 µGy to 1753.6 µGy. This hospital also operates with the highest ESD values across the dataset.

1. Statistical Analysis

Pearson correlation coefficients were computed for each hospital's dataset to evaluate the link between Charge (mAs) and Entrance Skin Dose (ESD). The degree and direction of the linear link between these two variables are measured by the Pearson correlation coefficient (r); a value nearer 1 denotes a strong positive correlation.

2. YMGH Hospital

At YMGH, the Pearson correlation coefficient between mAs and ESD was $r = 0.995$, indicating a near-perfect positive linear relationship. This result suggests that as the charge (mAs) increases, the ESD also increases in a highly predictable manner. The strong correlation reflects the direct dependency of radiation exposure on mAs, which is expected in radiographic procedures, where a higher mAs generally results in a higher radiation dose delivered to the patient. Therefore, reducing mAs would likely reduce ESD, making dose optimization critical for minimizing patient exposure while maintaining image quality.

3. SH Hospital

The correlation between mAs and ESD at SH was stronger, with a Pearson coefficient of r = 0.998. This nearly perfect correlation demonstrates that an increase in mAs leads to a proportionate and highly consistent increase in ESD. The strong correlation suggests that the dose at SH is directly influenced by the charge applied during procedures. This indicates an opportunity to manage radiation dose through careful control of mAs settings, as even small increases in mAs significantly impact patient exposure.

4. DCH Hospital

The Pearson correlation coefficient was r = 0.994, indicating a strong positive linear relationship between mAs and ESD. Similarly, this result confirms that the ESD rises sharply with increased mAs. This strong correlation underscores the importance of balancing mAs values to minimize radiation exposure without compromising diagnostic image quality. The strong linearity suggests that DCH could benefit from reviewing mAs settings, possibly through dose-saving technologies, such as automatic exposure control (AEC), to optimize radiation levels.

5. Comparison Across Hospitals

Across all three hospitals, the Pearson correlation coefficients were remarkably high (r > 0.99), indicating that the relationship between Charge (mAs) and ESD is both strong and consistent. These results reinforce the well-established relationship that higher mAs values lead to increased radiation doses. The significance of equipment settings, calibration, and operational practices in dose management is highlighted by the similarity in correlation among hospitals, even when the mAs and ESD ranges vary.

The charge used during X-ray treatments and the radiation dose given to patients are strongly and consistently correlated by statistical analysis. Because even minor changes to mAs can influence patient radiation exposure, these findings highlight the importance of carefully evaluating mAs levels in clinical practice.

b. The Contour Plot Among Tube Voltage (KVp), Charge (mAs), and Entrance Skin Dose (EDS) [μGy]

The contour plot in Figure 4 provides important information about how tube voltage (KVp), charge (mAs), and entrance skin dose (ESD) [μGy] interact in diagnostic radiology, especially when it comes to adjusting exposure settings to balance patient safety and image quality.

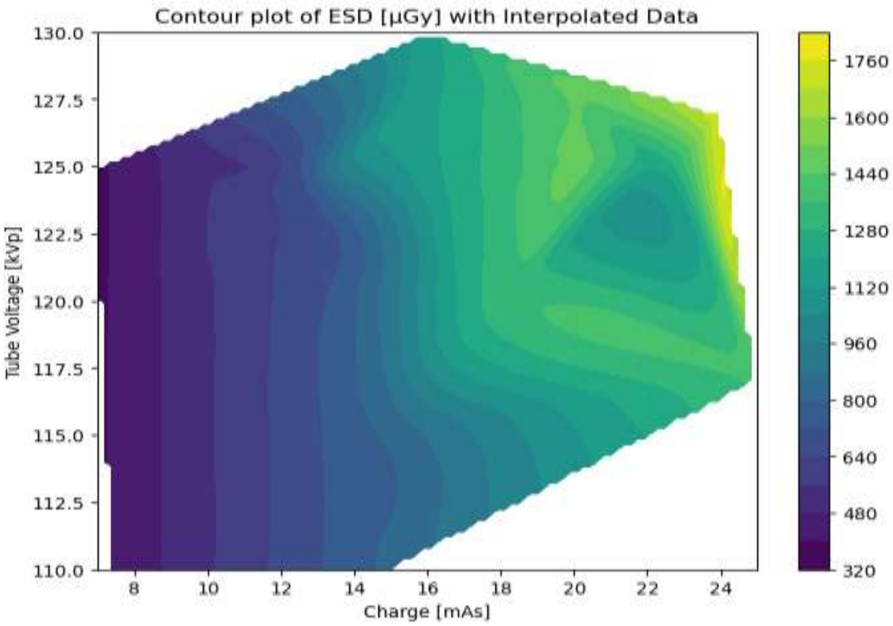

Figure 4. *The entrance skin dose (ESD) assessments in the hospitals in Dire Dawa, Ethiopia*

Entrance Skin Dose (ESD) and Tube Voltage (KVp): The contour plot probably indicates that the entrance skin dose shows a non-linear pattern as the tube voltage rises. This is expected as higher KVp produces higher-energy X-rays that more efficiently penetrate tissue, increasing the dose that the skin absorbs (Bushberg et al., 2011). Since higher KVp values tend to result in increased transmission through tissues, there may be a threshold at which the dosage grows more slowly because the skin surface absorbs less higher-energy X-rays.

The two have a generally linear relationship since a higher charge causes more X-rays to be produced, which raises the dose that is applied to the skin (Hendee & Ritenour, 2002). The purpose of the contour plot is to demonstrate that the ESD rises proportionately with mAs for a particular KVp. This emphasizes mAs levels carefully to reduce needless radiation exposure without sacrificing image quality.

The entrance skin dosage is mostly determined by the combined effect of tube voltage and charge. Because lower-energy X-rays are more readily absorbed by the skin, the contour plot probably shows that even slight increases in mAs result in a noticeable rise in ESD at low KVp levels. On the other hand, because of increased X-ray penetration and decreased surface absorption, the impact of increasing mAs on ESD may be less noticeable at higher KVp levels (Seibert & Boone, 2005). This interaction emphasizes how KVp and mAs must be balanced optimally based on patient-specific characteristics and diagnostic criteria.

The data presented in the contour plot can inform clinical practices aimed at optimizing exposure settings. By selecting an appropriate combination of KVp and mAs, radiologists can reduce the entrance skin dose while maintaining sufficient image quality for diagnostic purposes (Vano et al., 2017). For example, increasing KVp while reducing mAs can reduce the skin dose, though it may affect image contrast. Conversely, lowering KVp may enhance contrast and increase the dose if mAs are not adjusted accordingly.

The average ESD across the contour plot may indicate typical dose levels encountered during diagnostic procedures, providing a benchmark for comparison against recommended safety limits.

Standard Deviation: The variation in ESD across different combinations of KVp and mAs can reveal areas of the plot where the dose is most sensitive to changes in these parameters. This can help identify settings that may pose a higher risk of overexposure.

Correlation Analysis: A Pearson correlation analysis between KVp, mAs, and ESD could quantify the strength of the relationships between these variables. It is expected that mAs would have a stronger linear correlation with ESD, while KVp would show a more complex, non-linear relationship.

IV. Conclusion

The analysis of ESD values across the hospitals and types indicates variability in radiation doses, particularly for chest radiography in DCH. While the consistency within each hospital for abdominal radiography is commendable, efforts should be made to reduce the overall patient doses for chest radiography. Comparing it with other studies highlights the importance of continuous monitoring and adopting best practices to ensure patient safety in diagnostic radiography.

A statistically significant effect of milliampere-seconds (mAs) on radiographic outcomes has been found in the study of radiography data from DCH, YMWGH, and SGH. With extremely low p-values and high t-values, the mAs coefficient is highly significant, highlighting its crucial role in defining image quality and patient safety. This consistent finding across the institutions implies that limiting patient exposure and attaining acceptable radiography results need careful consideration of the mAs settings. On the other hand, the constant term's low t-values and high p-values show that it has no discernible impact on the results. This is consistent with other research showing that constant terms frequently make just a little contribution to these kinds of models.

These findings emphasize the significance of mAs in radiography procedures and recommend that rather than the constant term, resources be allocated to mAs settings optimization and refinement. To gain a deeper understanding of the factors influencing radiography outcomes, future studies should benefit from investigating additional significant variables and carrying out cross-hospital investigations. Overall, the results support the requirement for careful mAs setting management to improve the caliber and security of radiography exams.

Recommendations

1. Maintain radiography procedures within recommended bounds and review and enhance them.
2. Training and Awareness: Radiologic technologists should participate in ongoing education programs on dose reduction strategies and best practices.
3. Regular Equipment Maintenance: X-ray machines receive routine maintenance and calibration to prevent needless radiation exposure from equipment malfunctions.

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