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Comparative study of Radiation Doses Patients Received during X-ray Examinations in Dire Dawa Hospitals

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Abstract

Assessing and evaluating the exposed radiation dose absorbed by the patients during x-ray examinations is demanding. The aim of this study was to assess and examine comparatively the patient doses in the most common radiographic X-ray examinations in selected hospitals in Dire Dawa city, Ethiopia. Optically Stimulated Luminescence Dosimetry (OSLD) device was used in the laboratory to measure the x-ray tube output and its calibration. Moreover, a cross-sectional study design with quantitative and qualitative data was used to evaluate the obtained results.Examination parameters of 133 radiographs were exploited to evaluate the entrance surface air kerma (ESAK) of patients undergoing chest posterioanterior (PA), abdomen anterioposterior (AP), and lumbar spine anterioposterior (AP) in seven health facilities. Tube values of kV, mAs, and FFD used ranged from 54-119 kVp, 0.5-120 mAs, and 100-150 cm, respectively. Analyses were performed on measurements throughout the seven health facility radiological centers. Hospital means of ESAKs were estimated in a range from 0.13 – 1.540 mGy for chest PA, 0.470–4.538 mGy for Lumbar Spine AP, and 0.405- 4.905 mGy for Abdomen AP. In all hospitals, ESAK for chest exams is higher than the recommended values from International and national Diagnostic Reference Levels (DRL) except in two private health facilities, Yemariam Work Higher Clinic (YHC) and Bilal Hospital (BH). For the other examinations, the values were within the recommended values. In conclusion, The results of this study will be helpful to avoid unnecessary x-ray exposure hence preventing unwanted radiation associated complications and for the formulation of national reference levels as recommended. Due to relatively high tube output in all except two hospitals YHC and BH in chest PA x-ray examinations, it is recommended to increase in the filtration of exposures in these hospitals. In addition quality control of the darkroom is highly demanding in these hospitals. It is also concluded that radiographers adhere to guidelines for quality radiographs for standardizing their practice.

Keywords: Radiation dose; X-ray; Entrance Surface Air Kerma (ESAK), Radiograph

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1. Introduction

In both developed and developing countries, the number and range of X-ray facilities and X-ray equipment are increasing rapidly (UNSCEAR, S, 2000). The alternative modalities for diagnosis of diseases and injury, such as ultrasound and MRI, are becoming increasingly available; however, steady improvement in the quality of X-ray images and patient protection have ensured that diagnostic X-rays remain the most used tool in diagnosis (Muhogora et al, 2001). Hence make a major contribution to man’s exposure to ionizing radiation from man-made sources.

In recent years, health physicists have devoted much effort to the minimization of patients’ doses in diagnostic radiology. Through these efforts, substantial reductions in radiation doses to patients resulting from radiographic procedures have been achieved in many countries (Martin et al, 1999). Since medical physicist is a certified medical professional with education and clinical training in the safe and effective application of radiation in the fields of medical imaging and radiation therapy and is certified by the American Board of Radiology. A qualified medical physicist can play in managing radiation doses in medical imaging (McCollough, C. H, 2016).

The International Atomic Energy Agency has recommended guidance levels of dose for diagnostic radiography for a typical adult patient. These levels were intended to act as thresholds to trigger investigations or corrective actions in ensuring optimized protection of patients and maintaining appropriate levels of good practice. Since guidance levels should be derived from wide-scale surveys of exposure factors performed in individual hospitals (Mohammedzein, 2009).

The radioprotection of patients in imaging appears as a priority and particular attention is related to the practices to minimize radiation risk. Without compromising the effectiveness of the diagnosis or its therapeutic value, the overall goal is to reduce exposure to what is absolutely necessary. That is why any examination must be justified by its diagnostic contribution in relation to the irradiation, its realization must be optimal, that is to say, in conformity with the as low as reasonably achievable (ALARA) principle, and the doses delivered must be regularly evaluated for comparison with diagnostic reference levels, which should not be exceeded without justification (Gnowe et al, 2019).

Some dose surveys were conducted recently in Ethiopia. However previous studies cover only calculating the Entrance Surface Doses (ESDs) received by adult patients undergoing Posteroanterior (PA) chest X-ray examinations in major public health facilities in Addis Ababa, thereby establishing the first Ethiopian local diagnostic reference levels (LDRLs) as part of ongoing dose reduction program. Hospitals' mean ESDs for adult PA chest X-ray examination were found in the range of 0.76 to 1.48 mGy (Teferi et al, 2010). However, Most of the ESD measured doses were slightly greater than the National Radiological Protection Board (NRPB), Commission of European Community (CEC), and International Atomic Energy Agency (IAEA) reference doses. For the purpose of radiation protection mechanism before the patients absorb some amount of unnecessary dose of radiation, estimation and determination of ESAK offers superior and reliable result compared to ESD. Moreover, the previous studies cover only in Addis Ababa, Ethiopia major Hospitals and even it is done for only one part of the body, i.e. PA chest x-ray examinations. And also, other study is done on the Radiation Levels from Laboratory Wastes and Pharmacy Items at Four Hospitals in Harar and Dire Dawa Towns.

Therefore, the aim of this study was to evaluate patients' doses arising from X-ray examinations of various projections such as abdomen anteroposterior (AP), chest posteroanterior (PA), and lumbar spine anteroposterior (AP) excluding pediatric patients at selected hospitals in Dire Dawa city, Ethiopia during. Results from this study will serve as a useful baseline tool to modify as well establish national reference levels. It was anticipated that the study will help in the optimization of radiation protection of the patient. The patient dose was estimated in the present study in terms of Entrance Surface Air Kerma (ESAK).

2. Materials and methods

In this study, Optically Stimulated Luminescence Dosimetry (OSLD) was used for measuring the tube output and it is calibrated at Secondary Standard Dosimetry Laboratory (SSDL) of the Ethiopian Radiation Protection Authority (ERPA). The study used a cross-sectional study design with quantitative and qualitative data to evaluate the radiation dose patients received during radiographic x-ray examination.

This study was conducted in two government hospitals and five private health facilities which have radiological unit in Dire Dawa city, Ethiopia. Seven X-ray units were included in this study. The hospitals which participated in this study were Dilchora Referral Hospital (DRH), Sabiyan General Hospital (SGH), Art General Hospital (AGH), Bilal General Hospital (BGH), YeMariamWork General Hospital (YGH), YeMariam Work Higher Clinic (YHC), and Iftu Specialized Clinic (ISC). All seven health facilities which has radiologic units in Dire Dawa were included in this study.

In this study, non-probability purposive sampling method was used to evaluate radiation dose patients received during radiographic x-ray examinations. The sample size of the study was 133 radiographs of adult patients who were ≥20 years with three different projections coming for examination during the study period between March 2022 to May 2022. The primary qualitative data collection method was used to acquire primary data using observation and measuring on evaluation of radiation dose patients received during radiographic x-ray examinations. For each patient, Sex, Age, and type of examination (chest, abdomen, and lumbar spine) with their projections were documented in the format. In addition, exposure parameters like tube potential (kVp), milli Ampere (mA) milli Second (mS) exposure current-time product (mAs), focus to film distance FFD (cm), and tube output was recorded by the radiographers at the time of examination for each patient during exposure. Then after, the proposed LDRLs were compared with the national and international reference dose values reported by the Commission for European Community (CEC), the International Atomic Energy Agency (IAEA), and the National Radiological Protection Board (NRPB). Microsoft Excel was used for data manipulations and ESAK calculations.

3. Results and Discussions
3.1 Results

This study was carried out in seven health facilities in Dire Dawa city, Ethiopia. Seven X-ray units were included in this study. Tables: 3.1 to 3.7 shows the Patient exposure parameters and ESAK for all selected X-ray examinations during the study. In these tables; kV, mAs and FFD used ranged from 54-119 kVp, 0.5-120 mAs, and 100-150 cm, respectively. Analyses were performed on measurements throughout the seven radiological hospitals. The distribution and mean values of ESAKs for individual adult patient exposures are presented with three different projections. For Abdomen AP and Lumbar Spine AP x-ray examinations, all doses were below the corresponding IAEA levels. But for Chest AP x-ray examinations, except for two hospitals, the others are above the recommended values. It can be seen from the Tables that the doses presented in the hospital (YHC) were lower compared to the doses in other hospitals included in the study. This can be described by the relatively lower X-ray tube output parameters used. In all examinations by average (Chest PA, Abdomen AP, Lumbar Spine AP) the highest values of ESAK was found in DGH hospital. This is because of the relatively high tube output parameters used in this hospital. The variations in these parameters, as reflected in the range values, are partially due to variations in patient size and technique used.

Table: 3.1 Patient exposure parameters and ESAK for selected X-ray examinations in Sabiyan General Hospital (SGH*)*

No	Projection	Sample Size	kV	mA	mS	mAs	FFD	ESAK
1	Chest PA	7	54	152	156	24	150	0.610
2	Abdomen AP	7	62	151	145	22	100	1.528
3	Lumbar Spine AP	7	70	230	176	42	100	3.139

Table: 3.2 Patient exposure parameters and ESAK for selected X-ray examinations in Dilchora Referral Hospital (DRH)

No	Projection	Sample Size	kV	mA	mS	mAs	FFD	ESAK
1	Chest PA	7	71	19	-	-	150	0.711
2	Abdomen AP	-	-	-	-	-	-	-
3	Lumbar Spine AP	-	-	-	-	-	-	-

Table: 3.3 Patient exposure parameters and ESAK for selected X-ray examinations in Bilal Hospital (BH)

No	Projection	Sample Size	kV	mA	mS	mAs	FFD	ESAK
1	Chest PA	7	119	331	13	4	150	0.186
2	Abdomen AP	7	74	253	204	51	100	2.254
3	Lumbar Spine AP	7	79	310	118	37	100	0.879

Table: 3.4 Patient exposure parameters and ESAK for selected X-ray examinations in Yemariam work Higher Clinic (YHC)

No	Projection	Sample Size	kV	mA	mS	mAs	FFD	ESAK
1	Chest PA	7	78	80	0.3125	25	150	0.13
2	Abdomen AP	7	74	100	0.157	15.7	100	0.866
3	Lumbar Spine AP	7	79	100	0.12	12	100	0.583

Table: 3.5 Patient exposure parameters and ESAK for selected X-ray examinations in Art General Hospital (AGH)

No	Projection	Sample Size	kV	mA	mS	mAs	FFD	ESAK
1	Chest PA	7	90	100	1.2	120	150	0.407
2	Abdomen AP	7	87	100	1.2	120	100	0.405
3	Lumbar Spine AP	7	87	100	1.2	120	100	0.470

Table: 3.6 Patient exposure parameters and ESAK for selected X-ray examinations in Iftu Specialized Clinic (ISH)

No	Projection	Sample Size	kV	mA	mS	mAs	FFD	ESAK
1	Chest PA	7	81	160	0.003125	0.5	150	0.568
2	Abdomen AP	7	74	189	0.006514	1.25	100	4.905
3	Lumbar Spine AP	7	81	200	0.006250	1.25	100	4.538

Table: 3.7 Patient exposure parameters and ESAK for selected X-ray examinations in DeltYemariam work General Hospital (DGH)

No	Projection	Sample Size	kV	mA	mS	mAs	FFD	ESAK
1	Chest PA	7	87	100	0.25	25	150	1.540
2	Abdomen AP	7	74	100	0.2	20	100	1.230
3	Lumbar Spine AP	7	78	125	0.1248	15.6	100	1.030

3.2. Discussions

Results in table 3.8 show ESAK for all examinations included in this study for the seven x-ray machines at seven hospital centers and the guidance levels recommended by the International Atomic Energy Agency (IAEA), the National Radiological Protection Board (NRPB), Commission of European Community (CEC).

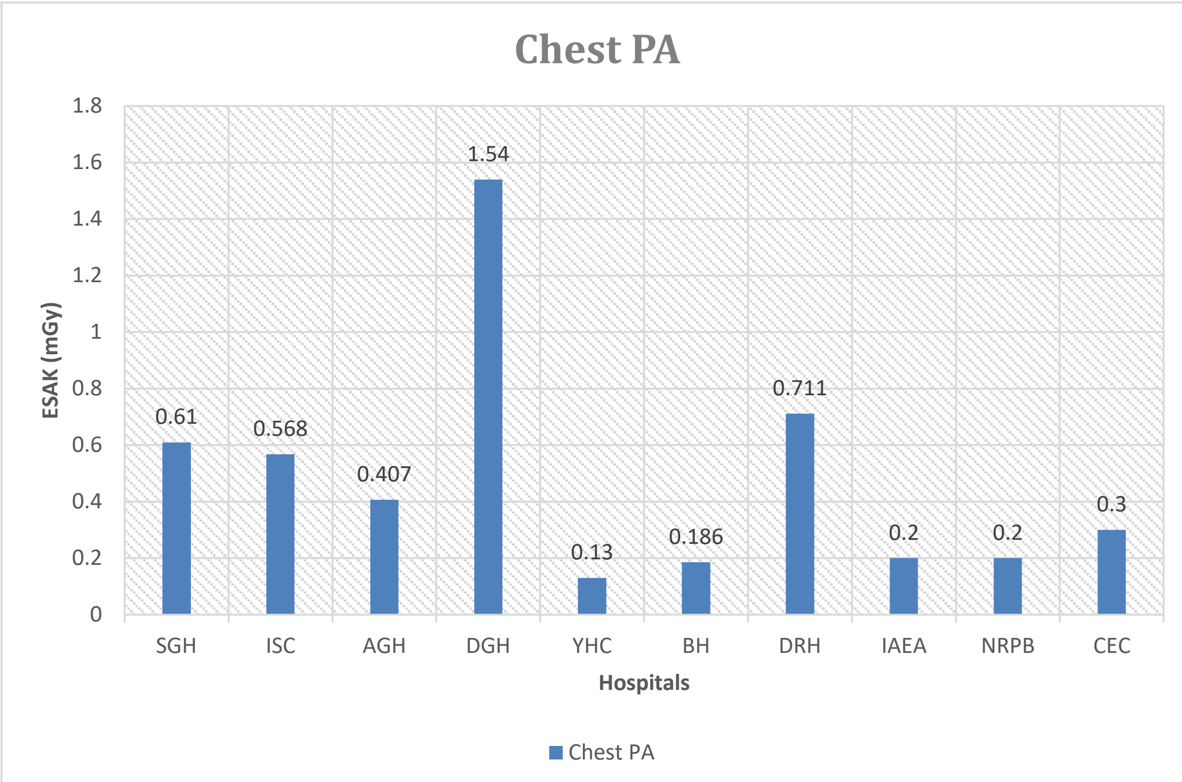
Table: 3.8 Mean ESAK (mGy) for all hospitals included in this study with IAEA &NRPB &CEC recommended guidance level

This Study								Organization with reference dose levels		
Projections	SGH	ISC	AGH	DGH	YHC	BH	DRH	IAEA	NRPB	CEC
Chest PA	0.610	0.568	0.407	1.540	0.13	0.186	0.711	0.2	0.2	0.3
Abdomen AP	1.528	4.905	0.405	1.230	0.866	2.254	-	5.0	-	
Lumbar Spine AP	3.139	4.538	0.470	1.030	0.583	0.879	-	5.0	6.0	10.0

From all observations (YHC) is the smallest value in Chest PA and (AGH) is the smallest value in both Abdomen AP and Lumbar Spine AP examinations because of the low output of the machine combined with high tube filtration.

In chest examinations, all hospitals showed ESAK values are higher than the IAEA reference dose except for two hospitals YHC and BH. This could be attributed to the relatively high exposure parameters used in these hospitals. It is also possible that the radiographers experience has some impact on the results. Similar characteristics in this study were that there was quality control (QC) performed for chemicals and film processing materials a factor that resulted in high technique factors used throughout this study. Based on the results obtained recommendations will make on how to bring the doses below the international recommended dose levels. In general all values of ESAK in this study within IAEA recommendation and exceed with fraction in some cases.

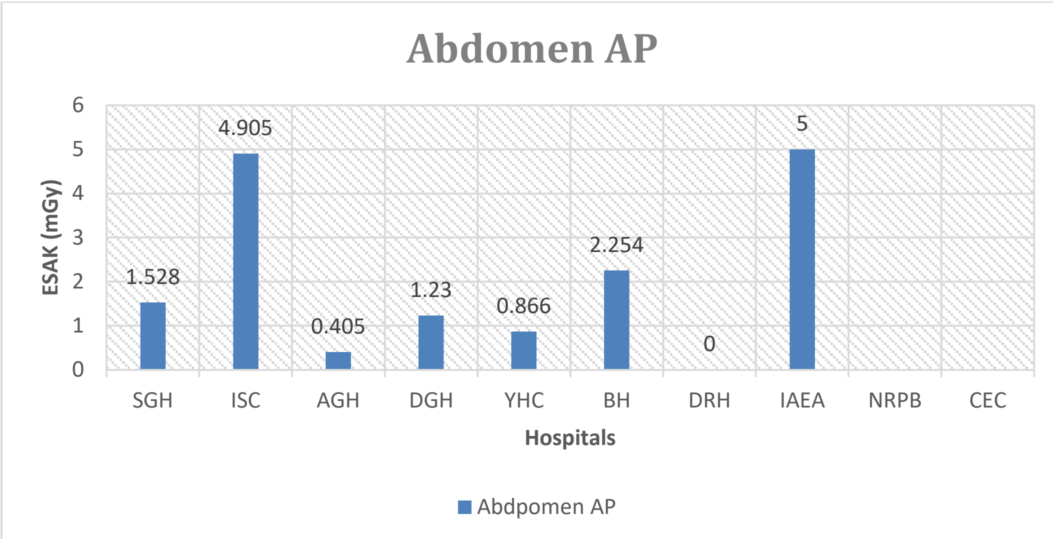
Figure: 3.2a The histograms of ESAK distribution for Chest PA x-ray examinations



Results in figure 3.2a show ESAK for all examinations included in this study for the seven machines at seven hospitals and the guidance levels that recommended by International Atomic Energy Agency (IAEA).

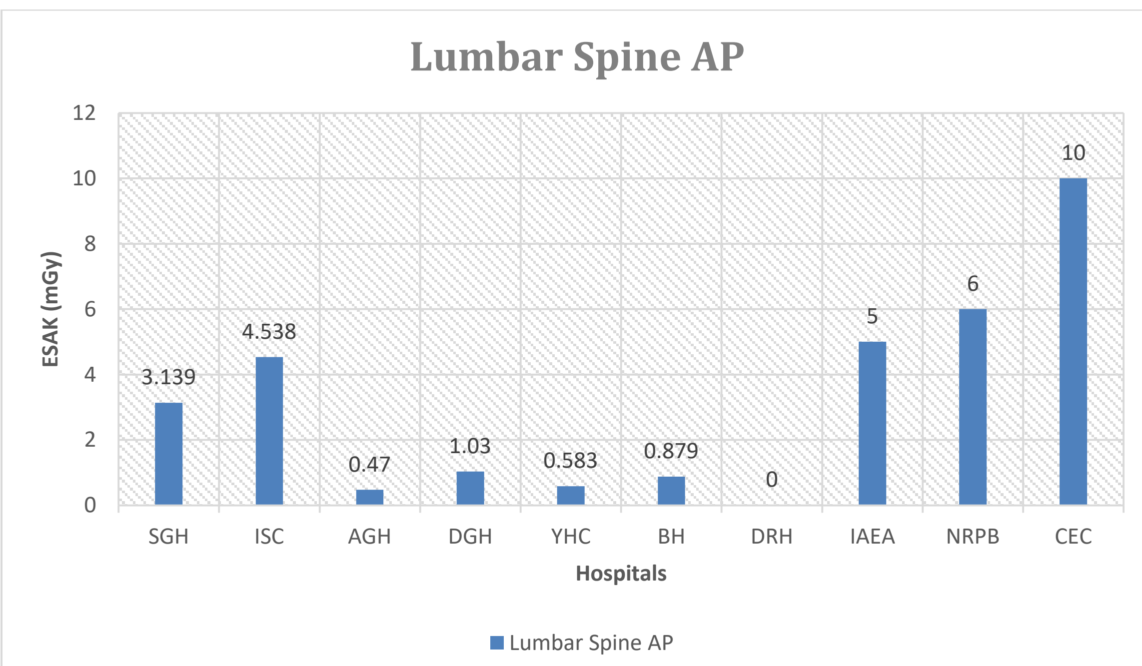
From the observations (YHC) is the smallest value and (DGH) is the highest value in Chest AP x-ray examinations from all selected hospitals because of the low output of the machine combined with high tube filtration. All health facilities showed ESAK values that are lower than the IAEA reference dose. This could be attributed to the relatively low exposure parameters used in these hospitals. Based on the results obtained recommendations have to be made on how to keep the doses to the international recommended dose levels.

Figure: 3.2b The histograms of ESAK distribution for Abdomen AP x-ray examinations



Results in figure 3.2b show ESAK for all examinations included in this study for the seven machines at seven hospitals and the guidance levels that recommended by International Atomic Energy Agency (IAEA). From the observations (AGH) is the smallest value and also (ISC) is the highest value in Abdomen AP x-ray examinations because of the low output of the machine combined with high tube filtration. Since the DRH x-ray machine didn't give examinations on Abdomen AP, the study couldn't record its value during the study period.

Figure: 3.2c The histograms of ESAK distribution for Lumbar Spine AP   x-ray examinations



Results in figure 3.2c show ESAK for all examinations included in this study for the seven machines at seven hospitals and the guidance levels that recommended by International Atomic Energy Agency (IAEA). From the observations (AGH) is the smallest value and (ISC) is the highest value in Lumbar Spine AP examinations because of the low output of the machine combined with high tube filtration at AGH. Since the DRH x-ray machine didn't give examinations on Lumbar Spine AP, the study couldn't record its value.

In the case of lumbar spine examinations all hospitals give ESAK values below the IAEA reference dose. This could be attributed to the relatively low exposure parameters used in these hospitals.

Generally, the result of this study demonstrates that some of the facilities need to maintain a better filtration mechanism for the higher output of machines, radiographers need to adhere the guideline of quality radiograph measurement practice and centers also need to standardize their facilities according to the quality control standards as of darkrooms to mention. Moreover, the study focuses on only a variable ESAK due to time and resource limitations. Hence, it is recommended a further nationwide study to be carried out by taking into account all relevant variables and factors related to radiation exposure and dose to better maintain and assure the national radiation dose base line and protect the patients as well other individuals from radiation effects.

4. Conclusion

ESAKs were estimated in the present study for patients undergoing selected diagnostic X-ray examinations at different projection in selected health facilities in Dire Dawa. The examination parameters of 133 radiographs were used to evaluate the entrance surface air kerma (ESAK) of patients undergoing chest posterioanterior (PA), abdomen anterioposterior (AP), and lumbar spine anterioposterior (AP) projections in seven health facilities. In this study kV, mAs and FFD used ranged from 54-119 kVp, 0.5-120 mAs, and 100-150 cm, respectively. Hospitals mean ESAKs at three different projections are estimated to range from 0.13 – 1.540 mGy for chest PA, 0.470–4.538 mGy for Lumbar Spine AP, and 0.405- 4.905 mGy for Abdomen AP. Analyses were performed on measurements throughout the seven radiological hospitals. This data will be useful for the formulation of national reference levels as recommended by the International Atomic Energy Agency (IAEA). Due to relatively high tube output in all except two health facilities YHC and BH in chest PA x-ray examinations, ESAK for chest exam is higher than the recommended value from IAEA, NRPB, and CEC DRLs. For the other examinations, the values are within the recommended values from IAEA, NRPB, and CEC.

Thus, the following recommendations can be made as increasing the filtration in relatively high tube output x-ray examinations especially for Chest PA in some health centers. Radiographers need to adhere to the guidelines for quality radiograph for standardizing their practice. In addition, quality control of the dark room is highly recommended. Moreover, It is anticipated that the results presented will serve as a baseline data needed for deriving DRLs for X-ray examinations in Ethiopia.

5. Acknowledgements

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6. Ethics approval

Approval was obtained from the local ethics committee, Dire Dawa Health bureau and Ethiopian Radiation Authority.

7. Conflict of interest

The authors declare that there is no conflict of interest.

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