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## ORIGINAL ARTICLE

# RELATIVE COLLECTIVE DOSE DISTRIBUTION OF COMPUTERIZED TOMOGRAPHY IN PUBLIC AND ARMED FORCE HOSPITALS IN ADDIS ABABA

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## ABSTRACT

***Introduction****: Recent developments in medical imaging have led to rapid increases in the number of high dose radiation examinations for individual patient and for collective dose to the population as a whole. It is, therefore, important to make regular assessments of the magnitude of these large doses in each country. The aim of the study was, therefore, to calculate the collective dose in the population as a result of radiation dose from diagnostic x-rays and Computed Tomography.*

***Methods****: Data on the number of diagnostic x-ray and computerized tomography examinations in six public and one armed force hospitals in Addis Ababa were collected by specific body area in the year 2015/16 .The number of examinations of specific body area were multiplied by the average effective dose per examination to get the collective dose over the population.*

***Results****: In the specified study period, a total of 134,894 diagnostic radiological examinations were performed in the seven hospitals. Approximately 88 % of them were conventional radiography, 11% were computed tomography and fluoroscopy examination contributed only for about 0.6%. The annual total collective effective dose to the population from radiological examinations were estimated to be 128 manSv of which 66.7% were due to Computed Tomography; whereas ~ 25% and 6% were contributed with conventional radiography and fluoroscopy examinations, respectively*

***Conclusion****: Computed Tomography was identified as the main cause of radiation exposure. Hence, further efforts for optimization of this risk should be made.*

***Keywords:*** *Collective effective dose, population exposure, ionization radiation, radiological procedure*

## INTRODUCTION

A precise determination of population exposure from medical use of radiation would require detailed knowledge of a number of procedures and patient doses for all procedures.

An EU-funded project called DOSE DATAMED (2004 - 2007) was set up to develop harmonized methods for future surveys of population exposure from medical x-rays & computerized cosmography (CT). Around the turn of the century, the collective effective dose for the "TOP 20" examinations ranged from 303 to 1421 mSv per 1000 population in Europe. In 2008 the figures ranged from 331 to 1521 mSv per 1000 population. However, the contribution to the "TOP20" from conventional radiography examinations has decreased, while the contribution from CT now is in the range of 46 -81 %( 1- 2).

Another study on ionizing radiation exposure of the population of the United States, in the early 1980's, showed that medical imaging accounted for 15% of the U.S. population's per capita exposure to ionizing radiation from all sources (0.54 mSv of 3.6 mSv).

In 2006, medical imaging accounted for 48% of the per capita exposure (3 mSv of 6.25 mSv), with CT, nuclear medicine and interventional fluoroscopy accounting for 24%, 12%, and 7%, respectively. Currently in the USA, the effective dose from medical exposure already exceeded the contribution of doses from the natural background radiation. This rise is largely attributable to increased exposure from CT, nuclear medicine, and interventional fluoroscopy (3, 4).

For example, the adult effective dose from a CT examination of the head & abdomen is equivalent to the adult effective dose from roughly 100 & 400 chest x-rays, respectively. While CT, interventional fluoroscopy, and nuclear medicine studies make up only approximately 26% of the imaging procedures using radiation conducted annually in the U.S, they contribute for 89% of the total yearly exposure to radiation from medical imaging (4-8).

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In Ethiopia, a study done in 2007 showed, the annual total collective radiation dose received by the population in seven public hospitals in Addis Ababa radiography came up with a dose figure of 28 manSv(1).
The current study is, therefore, conducted to calculate relative collective dose distribution of computerized tomography in seven hospitals in Addis Ababa which would be reduced further by applying optimization and justification principles.

## MATERIALS AND METHOD

The study was retrospective and included all diagnostic x-ray & CT examinations from September 2015-August 2016 in the study hospitals. In order to know the cumulative dose of radiation of CT & all diagnostic x-rays (for all 17 procedures) , the whole data were collected on the number of diagnostic procedures in six public hospitals & one army hospital by body site, in Addis Ababa. The Hospitals included in the study were Yekatit 12 hospital Ras Desta hospital, Zewditu Memorial hospital, Tikur Anbesa Specialized hospital, All Arica Leprocy Tuberclosis and Rehabitation Trainig (ALERT) hospital, Armed force general teaching hospital (AFGTH) and Saint Peter hospital. These hospitals were chosen for the study because they are the largest governmental hospitals in Addis Ababa in terms of workload. The examinations included eight and five body sites of plain radiographs and CT scans, respectively. All intravenous urography (IVU) studies and barium examinations of the gastrointestinal tract (GIT) series in the specified one year period were also recorded.

The number of examinations of a specific body site was multiplied by the average effective dose per examination to get the collective dose over the population. Since there is no study done in Ethiopia to estimate the average effective dose per examination, in this research the average effective dose per examination per body site was taken from suggested values by European commission as recommend by the previous study (1).

The data were entered into a table registering the number of x-ray & CT examinations in the specified period by body sites. The study was conducted after approval by the Research and Ethics Committee of the department of radiology which has the mandate to review research proposals below PhD levels for their ethical merits. After giving clear and detailed explanations to the hospital & department heads of respective hospitals about the objective of the study, permission was obtained for data collection.

## RESULTS

The examinations included in this study were all plain radiographs, CT, intravenous urography (IVU) & barium contrast studies of the GIT. The frequency for diagnostic X-ray & CT examination by body site in 2015/16 is presented in Table 1 and 2. As shown in Table 1, the highest and least examinations were performed at Tikur Anbesa Specialized Hospital and Zewditu Memorial hospitals, respectively. The results showed that in the year 2015/2016 the total number of diagnostic radiological examinations in the seven hospitals were 134,894. Approximately 88 % of them belong to conventional radiography, 11% were CT and Fluoroscopy examination contributes only for about 0.6%.

Table 3, shows number of diagnostic X-ray examination by body site compared to 2007. The annual total collective radiation dose received by the population in the six public & one armed hospitals from overall radiography examinations (Excluding CT examination) in 2015/16 were 57.83 manSv (Table 2); while in 2007, it was 28 manSv (1). The effective dose for all plain radiography examinations seems to increase except for skull x-ray compared to the previous study (1). This tendency also applied to the fluoroscopy examinations (except barium enema) as well.

The overall cumulative doses for each procedure are given in table 2. Data indicate that the overall dose to the patients undergoing radiological procedure in 2015/16 in seven governmental hospitals in Addis Ababa were about 128masv. Out of which 67% were from CT; while conventional radiography and fluoroscopy contributes for ~ 25% and 6%, respectively.

**Table1:** Distribution of diagnostic X-ray & CT examination by body site in each government hospitals in Addis Ababa in 2015/16.

| Type of exam | TASH | Zewditu | Yekatit | Ras desta | Saint peter | Alert | AFGTH | Total |
|---|---|---|---|---|---|---|---|---|
| **Cxray** | 22444 | 2647 | 7754 | 7278 | 9338 | 3614 | 5812 | 58887 |
| **Limbs** | 16208 | 560 | 2602 | 4400 | 709 | 5800 | 5472 | 35751 |
| **Dorsal spine** | 248 | 180 | 88 | 180 | 109 | 140 | 80 | 1025 |
| **Skull** | 426 | 2106 | 1413 | 1687 | 419 | 450 | 424 | 6925 |
| **Cervical spine** | 431 | 480 | 174 | 1053 | 65 | 135 | 407 | 2745 |
| **Abdomen** | 1026 | 802 | 293 | 445 | 90 | 80 | 110 | 2846 |
| **Shoulder** | 1120 | 220 | 300 | 400 | 110 | 230 | 320 | 2700 |
| **Lumbar spine** | 2096 | 2600 | 489 | 1200 | 183 | 700 | 947 | 8215 |
| **UGI Barium** | 108 | | | | | | | 109 |
| **Bowel** | 64 | | | | | | | 64 |
| **Ivu & Cug** | 460 | | | | | | 96 | 559 |
| **Esophagus** | 98 | | | | | | | 98 |
| **Abd/pelvic CT** | 2618 | | | | | | 649 | 3267 |
| **Chest CT** | 2156 | | | | | | 398 | 2554 |
| **Head & neck CT** | 5411 | | | | | | 1152 | 6563 |
| **Limbs ct** | 96 | | | | | | 52 | 148 |
| **T/L CT** | 1715 | | | | | | 727 | 2442 |
| **Total** | 56725 | 9595 | 13113 | 16643 | 11023 | 11149 | 16656 | 134894 |

**Table 2 :** Distribution of collective effective dose by body site in seven government hospitals in Addis Ababa in 2015/16.

| | Effective dose msv) Per exam | Number of exam | % of exam out total exam | Total collective effective dose (man sv) | % of collective E.D Out Of total C.D |
|---|---|---|---|---|---|
| Chest X-ray | 0.25 | 58887 | 43.65 | 14.7 | 11.50 |
| Limbs | 0.1 | 35751 | 25.50 | 3.5 | 2.79 |
| Shoulder | 0.25 | 2700 | 2.00 | 0.6 | 0.53 |
| Lumbar spine | 2.8 | 8215 | 6.08 | 23 | 17.97 |
| Skull | 0.1 | 6925 | 5.13 | 0.7 | 0.54 |
| Cervical spine | 0.7 | 2745 | 2.03 | 1.9 | 1.50 |
| Dorsal spine | 2 | 1025 | 0.75 | 2 | 1.56 |
| Abdomen | 1.8 | 2846 | 2.10 | 5 | 4.00 |
| Upper GI | 15 | 108 | 0.08 | 1.6 | 1.26 |
| Bowel | 12.5 | 64 | 0.04 | 0.8 | 0.62 |
| IVP | 4 | 559 | 0.41 | 2 | 1.74 |
| Esophagus | 15 | 98 | 0.07 | 1.4 | 1.15 |
| Head & neck Ct | 2 | 6563 | 4.86 | 13 | 10.25 |
| Thoracic-lumbar | 2 | 2442 | 1.92 | 4.8 | 4.05 |
| Chest Ct | 8 | 2554 | 1.97 | 20 | 16.58 |
| Abdominal & pelvic Ct | 10 | 3267 | 2.24 | 32 | 23.58 |
| Limbs Ct | 1.4 | 148 | 0.11 | 0.2 | 0.16 |
| Total | | 134894 | 100 | 128 | 100 |

**Table 3:** Number of Diagnostic X-ray examination by body site/year in 2015/16 as compared to 2007.

| Type of exam | 2007 | 2014/15 | Change (%) |
|---|---|---|---|
| **Cxray** | 40295 | 58887 | +31.6% |
| **Limbs** | 22034 | 35751 | +38.37% |
| **Shoulder** | 1332 | 2700 | +50.66% |
| **Lumbar spine** | 1601 | 8215 | +80% |
| **Skull** | 11210 | 6925 | -38.2% |
| **Cervical spine** | 1199 | 2745 | +56.3% |
| **Dorsal spine** | 725 | 1025 | +29.2 % |
| **Abdomen** | 2553 | 2846 | +10.3% |
| **UGI Barium** | 72 | 108 | +33.33% |
| **Bowel** | 127 | 64 | -49.6% |
| **Ivu** | 47 | 559 | +91.6% |
| **Esophagus** | 73 | 98 | +25.6% |
| **Total** | 80949 | 119920 | +32.5% |

## DISCUSSION

CT has the highest dose compared with other X-rays examination. One of the ways to achieve the largest reduction in radiation exposure may be to exclude the prescription of unnecessary or unproductive radiological examinations. Patient exposure can also be reduced by assuring that good radiographic technique is practiced. It is said that the fundamental objective of x-ray examination is to obtain optimum diagnostic information with minimum diagnostic exposure (1, 2,).

In this study, both the examination frequency and the collective effective dose from all radiography (Excluding CT ) examinations have increased by ~ 33 % & 49%, respectively compared to results from the earlier study((1)). They showed that though CT represented only about 12% of all radiology procedures, it contributed for ~70% of the total dose due to its high effective dose per examination, and it is thus a major source of exposure to the population. CT was, therefore, identified as the main area of radiation exposure concern to which more efforts for increasing optimization should be made.

In our study, out of the total 119,920 radiography (excluding CT) examinations taken in the seven hospitals in Addis Ababa, chest and limbs accounted for 49.10% and 29.81 %, respectively. They only accounted for ~15% and 3.5% respectively of the total annual effective dose received due to their low effective dose per examination.

Plain lumbar films & Plain abdominal films accounted for 23% & 5% of the total annual effective doses received followed by IVP, which were performed in only two hospitals, accounted for 0.52% of all examinations and for ~2.5% of the total effective dose, which is significant due to their relatively higher effective dose per examination. While in the 2007 study, out of the total 80,894 radiography examinations taken in seven hospitals in Addis Ababa, chest and limbs accounted for 46% and 26 %, respectively. They only accounted for 38.6% and 7.1%, respectively of the total annual effective dose received due to their low effective dosage per examination (1).

Compared to the previous study's findings (1), there are also huge differences in the use of lumbar spine x-ray, & IVP, that is why the collective effective dose from all radiography (Excluding CT examination) examinations have increased by~ 49% where as the frequency data increased by only~ 33 % due to their high effective dose per examination (Table 2).It is for example recognized that the frequency of skull x-ray & bowel examinations has decreased compared to the previous study (1), but this trend has been offset by the increase in CT examinations. The annual collective radiation dose received from diagnostic radiology in this study was 128 manSv (0.412mSv/ person). The average radiation dose received per person (0.412mSv/ person) was higher than that of the previous study (0.37mSv/person) (1).The comparison shows that the overall effective collective dose per capita in the seven hospitals in Addis Ababa is significantly below the average for European countries (about 1.1 msv) per capita.

This is explained by the fact that, out of the total radiography examinations taken in public chest x-ray which has lowest effective dose, accounted for the majority of examinations (15% of collective dose).

But as we mentioned above, both the examination frequency and the collective effective dose from all radiography (Excluding CT examination) examinations have increased by ~ 33 % & 49%, respectively Further, highly effective dose contributors like bowel (Barium studies) and dorsal spine radiography are not performed on a wider scale compared for example to European countries (2).

It is important that advances in imaging technology also provide increased medical benefits to large numbers of patients; while maintaining the efforts to keep unnecessary exposure to a minimum. Therefore, personnel educated and trained in radiation protection have to be fully involved in planning, dose measurement and optimization, and have to initiate necessary radiation safety trainings for the medical staff, including those who refer patients for investigations. Strict guidelines need to be developed so that referring physicians carefully weigh the benefits against the potential risks and base their decisions on medically relevant data.

***Conclusion***

This study showed that CT though representing only about 12% of all radiology procedures in Addis Ababa, it contributes to~70% of the total dose and is thus a major source of exposure to the population. CT was, therefore, identified as the main area to which more efforts for increasing optimization should be made.

***Recommendation***

A medical imaging exam that involves exposure to ionizing radiation must be justified on the basis of benefit to the patient. Finally, we recommend that the findings of the present work can be used as a baseline upon which a large scale study including all hospitals in Ethiopia should be done..

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