Arab American University
Faculty of Graduate Studies

"Assessment and a Comparison of Pediatric Brain CT scan Dose Index CTDI vol & DLP in Palestinian Government Hospitals (West Bank) With IDRLs"

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Thesis Approval

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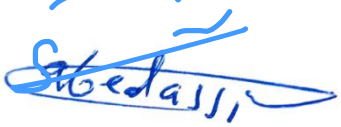
2. Dr. Samer Mhanna	Internal Examiner	
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Declaration

I certify that the master's thesis I have submitted is the result of my research unless otherwise stated and that it has not already been submitted to another university or organization for a higher degree.

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Abstract

Background. More than 2,200 CT scans of children's brains without contrast are performed in one month in government hospitals (GHs), according to the data of 16 CT scanners in GHs in the West Bank, in addition to more than 24 other CT scanners in private hospitals. The Ramallah Medical Complex conducts the equivalent of 3,000 CT scans per month, including 200 brain CT scans for children without contrast. Therefore, the risk of cancer increases linearly with radiation dose and decreases gradually with age according to multiple studies, so increasing the number of pediatric CT scans could increase this risk.

The purpose of this study. Is to assess the risks of radiation in pediatrics during brain computed tomography diagnostic procedures in G.Hs by calculating the radiology parameters of the imaging protocols (CTDI $_V$ & DLP) values that can be observed in the dose reports and comparing them with the international dose reports, because protecting children from ionizing radiation in medical applications, especially computed tomography of children's brains is very important, it was therefore necessary to measure the patient's dose to verify that the radiation dose was acceptable by comparing it with the published DRL.

Method. A sample was taken retrospectively from the tomography devices in G.Hs for all pediatric patients who had a tomography of the brain without contrast media between the period 1/12/2022 - 28/2/2023, and then calculated the median and the third quartile are the mean of CTDI $_V$ and DLP, it was collected from the top medical institutions of the following age groups, > 1, <1−5, <5-10, <10-15, and <15-18 years old, then compare the results that were statistically significant ($p \leq 0.05$), with international measurements and then give results and recommendations

Result. Total values (CTDI $_V$ and DLP) of all GHs by age groups were high compared to the rest of the countries. (The percentile 75% CTDI $_V$ >1 Year = 55.20, <1-5 Years = 55.20, < 5-10 Years= 55.20, <10-15 Years 55.40, <15-18 Years = 56.14 mGy. (The percentile 75% DLP, >1 Year = 1066, <1-5 Years = 1182, <5-10 Years= 1276.87, <10-15 Years 1303.05, < 15-18 Years = 1383.59 mGy.cm

Conclusion. The results showed that there were differences in dose values DLP & CTDI$_V$ among the CT devices that can mainly be attributed to differences in examination of the protocols and techniques used and utilizing comparatively various scan parameter values (kVp, mAs, scan time, slice thickness, and pitch), which led to differential exposure dosages for the same CT exams.

According to the study, children who underwent brain CT scans in GH$_S$ received higher doses of radiation than those in other countries. A significant difference in the CTDI $_V$ radiation dose index was also observed from one hospital to another despite having the same CT scanner.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

Abbreviation	Meaning
CT	Computed Tomography
CTDI $_{vol}$	Volume computed tomography dose index
DRLs	Diagnostic Reference Levels
DLP	Dose Length Product
mGy	Milli-Gray
ED	Effective Dose
PMC	Palestine Medical Complex
SNR	Signal-to-noise ratio
AEC	Automatic exposure control
MRI	Magnetic Resonance Imaging
MDCT	Multidetector Computed Tomography
MSAD	The Multiple-Scan Average Dose
ALARA	As Low as Reasonably achievable
mSv	Milli Sieverts
mAs	Milli Ampere-Seconds
kVp	Peak Kilo voltage
EC	European Commission
UK	United Kingdom
ICRP	International Commission on Radiological Protection
AAPM	American Association of Physicists in Medicine
ACR	American College of Radiology
UK	United Kingdome

MOH	Ministry of Health
EU	European Union
FDA	Food and Drug Administration
PACS	Picture Archiving and Communication System
GHs	Government Hospitals
AGH	Alia Governmental Hospital or Hebron Governmental Hospital
BGH	Al-Hussein Governmental Hospital- Beit Jala hospital
RGH	Rafidia Hospital Nablus
JGH	Martyr Khalil Suleiman Governmental Hospital – Jenin hospital
SGH	Martyr Yasser Arafat Governmental Hospital or Salfeet hospital
TGH	Tubas Turkish Governmental Hospital
QGH	Darwish Nazzal Governmental Hospital –Qalqilia hospital
RMC1	Ramallah Palestine Medical Complex 1(Emergency department)
RMC2	Ramallah Palestine Medical Complex 2(Ramallah sons' section)
RMC3	Ramallah Palestine Medical Complex 3 (Ramallah sons' section)
YGH	Abu Al-Hassn Governmental Hospital – Yatta hospital
ANOVA Test	Analysis of Variance
QC	Quality Control
MQC	The modified quality control based
FOV	Field of View
UNSCEAR	UN Scientific Committee on the Effects of Atomic Radiation
LDRLs	The Local Dose Reference Levels
NDRL	The National Dose Reference Levels
IDRLs	International Dose Reference Levels
EDRLs	European Dose Reference Levels

ASiR	Adaptive Statistical Iterative Reconstruction
FBP	Filtered Back Projection

Chapter One

Introduction

This chapter provides the background, problem statement, justification, aim, and, objectives of the study, Research questions, achieving the ideal radiation dose, Pediatric CT Radiation Risks, Justification and importance of the research, and Research Limitations.

1.1 Background

A CT scan is a diagnostic imaging process that creates images of the inside of the body using a combination of X-rays and computer technologies.

Any aspect of the body, including the bones, muscles, fat, organs, and blood arteries, is shown in detail. The X-ray beam rotates in a circle around the body during a CT scan. This gives detailed images of the same organ or structure from numerous angles. The X-ray data is transmitted to a computer, which analyses it and shows it on a monitor in two dimensions. Three-dimensional graphics are now achievable thanks to newer technology and computer software.

CT scans may be carried out to assist in the diagnosis of cancers, to look into internal bleeding, or to look for other internal injuries or damage. (Gricienė and Šiukšterytė, 2021) A tissue or fluid biopsy can also be performed using CT.

Since the development of X-rays and the first brain scan performed at Atkinson Hospital in 1971, computed tomography has represented the greatest advancement in medical imaging.(Schulz, Stein and Pelc, 2021).

The usage of CT scans in healthcare has increased significantly in recent years.

Now with the development of Multidetector Computed Tomography (MDCT) and the increase in the width of the detector. The MDCT scan has become a widely accepted test, as it is highly accurate and an excellent diagnostic and treatment technology. Therefore, it became the MDCT examination that is performed frequently (Karlen et al., 2013).

There are an estimated 375 million (CT) procedures performed each year globally (Gottumukkala al., 2019), with an annual growth rate of between 3% and 4%, Over 60-80 million CT scans are performed annually in the United States. Over the past one to two decades, CT use has significantly expanded, with pediatrics CT. Scan of at least 10% growth annually.

Currently, pediatrics account for 11% of CT scans performed, which might translate to more than 7 million pediatric CT scans annually in the United States. The frequency of CT examinations in adult and pediatric populations has increased due to the use of CT for common issues such as trauma (closed head injury, skeletal evaluation including cervical spine assessment, abdominal trauma, appendicitis, and calculi in renal) The majority of doctors think that CT scans of young patients prevent the need for hospitalization for head traumas (Bajoghli et al., 2010).

There are 16 devices CT scans in government hospitals in the West Bank, in addition to more than 24 other devices in private hospitals, The equivalent of 3,000 CT scans is performed per month at the Ramallah medical complex, of which 200 are brain pediatric without contrast, while more than 2,200 are performed brain CT scan pediatric without contrast in government hospitals per month. Today computed tomography (CT) is the most important source of radiological medical examinations for patients and accounts for more than 70% of the total population exposure.

Computed tomography (CT) scans of the brain of pediatrics (with or without contrast material) are often performed for various clinical reasons. So, Radiation parameters must be calculated to determine the relative radiation hazard. The first reason to understand the radiation dose from a CT scan is the risk of radiation. So, CT dose estimation is required to decide on the benefits and risks of the procedure to reduce the radiation dose for pediatrics during brain imaging, the researcher calculated the parameter values for CT scans in government hospitals and determined the dose of pediatric brain CT scan CTDI v and DLP.

1.2 Study Problem

Pediatrics overdosing during a brain CT scan is the main issue for the research. Low-dose CT is also an important area of research.

Therefore, it is important to reduce the patient's exposure to radiation and adhere to the **ALARA** principle. Reducing the radiation dose for the patient leads to a decrease in the number of radiation photons per pixel, which leads to a decrease in image quality (Jimoh, 2013). Pediatric overdose exposure during brain tomography is the research's main issue. Radiation sensitivity is higher in pediatrics (Dose et al., 2011). Protecting pediatrics from cancer because of their exposure to excessive radiation during a CT scan of the brain (Buls et al., 2010).

1.3 Study Objectives

1.3.1 The Main Objective

The purpose of this study is to assess the risks of radiation in pediatrics during brain computed tomography diagnostic procedures in government hospitals by

calculating the radiology parameters of the imaging protocols (CTDI $_{v}$ & DLP) values that can be observed in the dose reports and comparing them with the international dose reports.

1.3.2 Secondary Objectives

Two leading indications that show the reference points that aid radiology staff in seeking and maximizing CT methods are dose and image quality. Moreover, this research will establish a local Diagnostic Reference Levels, which will enhance the procedure of the common pediatric CT exam that can reduce patient dose during CT scanning

This study aims to establish the local Diagnostic Reference Levels measurements, which will contribute to adding information about the radiation dose given to pediatrics in government hospitals, which can provide medical care with the lowest radiation dose with high imaging quality.

1.4 Research Questions

What are the indicators of Diagnostic Reference Level (DRL) based Brain pediatric CT scan without contrast, are current calculated DRLs, CTDI v, and DLP different from those based on universal values, What are the primary determinants of the radiation dose, and are there a strong relationship between the key variables, pitch, length, KVP, mAs, and scan time?

1.5 Achieving the Ideal Radiation Dose

Radiation exposure from CT can be minimized by avoiding unnecessary or repetitive scans, adhering to the patient's dose recommendations, and using other radiography methods as required (Almohiy, 2014).

The use of ALARA recommendations can assist institutional efforts to balance radiation dose and image quality for pediatric patients to prevent unnecessary ionizing radiation exposure. Radiology staff must make sure that radiation danger is kept to a minimum by selecting the best approach utilizing the ALARA principle. This clinical report's content is being made available to support discussions with patients, relatives, and members of the healthcare team as well as decision-making (Brody et al., 2007).

Fellow enhanced protection will improve the efficiency of image scanning such as using thyroid shields with automatic tube current modulation (ATCM) can reduce thyroid doses from neck CT scans by 85 % (Kalender et al., 2008).

1.6 Pediatric CT Radiation Risks

There are two broad categories of effects that radiation exposure can have on human health: deterministic effects and stochastic effects. Cell destruction causes deterministic effects, the severity of which increases with the exposure dose.

The basic risks in diagnostic X-ray examinations, including computed tomography, arise from stochastic effects, which, depending on the dose taken, can lead to cancer.

The risk of cancer increases throughout life and increases linearly with the radiation dose. These studies (Rashighi and Harris, 2017).

Also showed that children are more sensitive to radiation than adults and that, for most types of cancer, the risk of developing cancer steadily decreases with increasing age

of exposure. There is a consensus that a computed tomography scan is beneficial and greatly outweighs the hazards (Brody et al., 2007). The increasing overuse of CT has raised concerns about patient safety, especially for pediatric patients who could be exposed to dangerous levels of ionizing radiation during the examination. According to the 2010 report of the UN Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), the tissues, and organs of children are particularly exposed to radiation, they are more susceptible to radiation-induced cancer than adults. (Muhammad et al., 2020). Radiation sensitivity is higher in pediatrics (Dose et al., 2011). The thyroid gland and the lens of the eye are exposed when a child's brain is imaged, and because they are among the most radiation-sensitive organs, they may develop cataracts (Buls et al., 2010). The incidence of CT-related neoplasia or mortality was predicted or assessed in sixteen research, which was found and examined.

Pediatric patients (>1–18 years old) who have brain CT scans have been shown in epidemiological studies to be more likely to develop tumors (Greater than average risk of a new brain).It is estimated that a child's radiation dose is significantly more carcinogenic than an adult dose for several reasons. First, rapidly developing and dividing cells, as well as growing tissues and organs, are more susceptible to the effects of radiation than fully mature ones. Second, children have longer lives in which to develop radiation-related cancers. Third, CT scans were often performed without considering the small size of the children (Frush et al., 2003). The mean tumorigenicity for pediatric subjected to one or more CTs was 1.29 (95% confidence interval, 0.66-1.93). The number of pediatric brain CT scans at the recommended dose was associated with an increase in tumor incidence. Even after a single inspection, there is a discernible excess. According to accumulating data from epidemiological research, having a CT scan even slightly

increases a patient's risk of developing a brain tumor. However, thorough epidemiological methodologies are required to control for constitutive variations, such as people with pre-existing cancer or cancer susceptibility that may help revert causality.

The study also indicates that the risk exists and assumes that tumor induction by computed tomography of the pediatric brain is very weak it may increase the risk of cancer 3000-10000 repeated scans (Sheppard et al., 2018). The risk of brain cancers is increased by the radiation exposure associated with CT scans. Additionally, no link to leukemia was found. (Meulepas et al., 2019).

1.7 Justification and Importance of the Research:

The study is important because it will shield children against radiation risks as well as risks associated with cancer, cataracts, and thyroid issues (Sheppard et al., 2018). Radiation exposure has been reduced due to developments in the field of tomography. Therefore, to benefit from international standards for radiation reduction and protection, it is necessary to maintain the pace of research and development. The CT instrument lives longer and requires less maintenance when a lower amount of radiation is used.

1.8 Research Limitations

This research on local DRLs in the West Bank / Palestine (Government hospitals) was, the first of its kind previous investigations carried out in the West Bank / Palestine were therefore inadequate and lacking in expertise.

Also, the lack of resources, such as the absence of phantom, which was used to build DRLs. Moreover, the absence of Jericho Hospital from the study because of the

Unavailability of dose report data on the CT system and archiving system for patients are some of the limitations of the research.

Chapter Two

Literature Review

Introduction

This chapter provides the background, previous studies and Literature Review, radiation protection, Image quality, and Considerations for DRL surveys in pediatric CT scans.

This chapter provides the CT scan parameters, the main dose measurements for computed tomography, Helical (Spiral) Scanning, and CT Dose Optimization.

2.1 Background

Since CT was first developed in the 1970s, its use has rapidly risen because of its outstanding diagnostic accuracy, availability, quick acquisition time, and other factors. (Nagayama et al., 2018). In this context, estimations from risk models and results from recent large-scale epidemiologic studies have predicted that, in radiosensitive pediatrics and adolescents, the risk of cancer linked with CT radiation exposure increases with increasing radiation dosage (Tepper, 2008).

To enhance the use of pediatric CT, spiral CT scanners with slip-ring technology are being introduced. CT is increasingly being used on children and new-borns. The most frequent procedure carried out in pediatrics is a brain CT. For CT operations LDRLs and DRLs are used to estimate dose indications (CTDI vol, (DLP). As a result, numerous researchers worldwide have studied radiation dose indicators in CT scans (CTDIv, DLP), particularly when imaging pediatrics, to confirm the accuracy of the settings and the potential for adjusting them to avoid high exposure to unjustified radiation doses on

patients. To identify and track dose indicators, Diagnostic Reference Levels (DRLs) in pediatric CT scans, and specifically the brain CT scan, the researcher retrospectively reviewed several previous articles. From this review, recommendations for obtaining local DRLs were made.

2.2 Previous Studies and Literature Review

There is no previous general national study in Palestine on DRLs, but there are studies on the Assessment of Effective Dose from Brain CT (ALMasri et al., 2012). Moreover, a study on the Towards Establishment of National Diagnostic Reference Levels (DRLs) in Palestine: Assessment of the Diagnostic Reference Levels for CT adult patients in the Non-Governmental Medical Centers in the West Bank-Palestine.

In a study for evaluation of radiation dose indicators (CTDI vol and DLP) at private (non-governmental) Palestinian hospitals and medical centers, for adult computed tomography (CT) scans for routine examinations, all data were collected through tests, including CTDI vol, DLP, and other acquisition parameters. Over three months, this investigation was completed routinely (examinations of the lumbar spine, thorax, abdomen, and brain).

The results showed that the average doses in private and non-governmental facilities were generally within the average ranges of different countries used as a reference in this study.

The age group of the patients was not specified in this study, and the study included multiple examinations and was not limited to a specific examination, which limits the strength of the results (Sabbarneh et al., 2019)

This multi-center study examined radiological practice and patient doses for five routine CT exams across five age ranges to evaluate the CT exposure of pediatrics in Belgium.

A collaboration of Belgian research teams that specialize in pediatric CT, including radiologists and medical physicists, carried out the study. The investigation was started in 2007, and information was gathered and evaluated up to 2009. Eighteen hospitals representing 21 radiology centers took part in the trial after receiving a nationwide mailing. The hospitals were scattered throughout the entire Belgian region (7 university hospitals and 11 general hospitals). Dosimetry measurements were made during local audits by a team of medical physics specialists by figuring out the typical CT dose descriptors for each distinct CT examination technique that was used for pediatrics. In this multi-center investigation, 18 hospitals with 21 CT scanners were all Multi Slice CTs (MSCT), of which 43% were 64-slice CT scanners that were at the cutting edge of technology. High-end scanners typically come with cutting-edge radiation protection features like automated tube current modulation (ATM), tailored pediatric scan protocols with lower kV, adaptive collimation to lessen the effects of over-scanning on spiral CT, and the display of dose descriptors for any given scan.

The pediatric CT dosage optimization process benefits greatly from these techniques.

The general results of the image quality evaluation show that the diagnostic quality of the CT scans is better than average. All other studies were rated between average (score 5) and very good (score 8). The combination of the results of the image quality evaluation with the dose levels from the audits is not very conclusive due to incomplete data. However, some interesting observations can be made for the head examinations as this

represents the most data. For the head examinations, the lower image quality scores agree roughly with the lowest doses. The best image quality scores are achieved from centers with a CTDI vol around 30 mGy, which is also the observed third quartile value 37 of all centers in the dosimetry audit.

This study is thought to be more thorough than earlier research. It stated which age group was under investigation. Additionally, it covered and defined imaging techniques and the ensuing pediatric imaging guidelines. This maintains image quality and lowers the radiation dose for the patient while achieving values compatible with global values, and we believe that if this study was repeated today with the advancement of tomography devices, the results would be more accurate and superior because this study was completed in 2010 (Buls *et al.*, 2010).

The Local Dose Reference Levels (LDRLs) were generated from common pediatric CT scans in Australia (Brady et al., 2012). and compared to global (DRLs). The values were similar to the universal values ، the study was not limited to a single examination, but multiple examinations of CT imaging

(Saravanakumar et al., 2016). They did a study to suggest South Indian Diagnostic CT Reference Levels (DRLs)And throughout a whole year Radiation doses for the most commonly used CT scans were pooled From 110 CT sites To determine the mean value of CTDI vol and DLP for the site then dose information such as volumetric CTDI vol dose index (CTDI vol) and dose length product (DLP) were recorded on at least 50 mean-volume patients in each class by integrating all results, DRL was determined for each site and region using approximately the 75th percentile. The results were compared with internal values in India as well as global values Results: Data for 16,500 patents were gathered. All of the devices featured multi-slices (2-256 slices) capability. Values were

lower than the DRLs in use today and are in line with previous international studies.

A study conducted in Cameroon (Moifo et al., 2017) was conducted on more than 696 middle-aged adults, The sample was randomly selected from each medical center and DRL was defined as the 75th percentile from DLP and CTDI vol the results showed that the total CT exam 41.2% of its Brain, 26.9% Abdominal Pelvis, 17.7% Lumbar vertebrae and 14.2% Thoracic. She explained that the sex ratio was 1.26 (55.9% male). The study was applied to CT scans (detectors 4, 8, and 16); the values were located in an area between the standards of some European and some African countries. It was noted that the most common CT tests in Cameroon have a noticeable variation in dosage, which necessitates the improvement of these established DRLs and the establishment of national DRLs. This study was not based on advanced computed tomography devices, as it was conducted in 2016.

Computed tomography studies of pediatrics, which were conducted in Australia from January 2010 to March 2014, retroactively to determine the seventy-fifth and ninety-fifth percentile of each computed tomography dose by volume. The study used for the creation of LDRLs for pediatrics CT scan examinations measured DRL performance with locally and internationally published Pediatrics studies.

The 75 percent local derivative of DRL is acceptable when compared with those published by the Australian National Register of Radiation Doses and two national children's hospitals and at the international level with UK national reference doses. The percentages of CTDIv were found for various tomographic examinations to be acceptable values for the notification of the CT scanner dose check. CT scanning shows that they follow the established protocols for different tests without significant differences in device setup grant a DRL derivation evaluation tool and improve CT service performance

through enhanced compliance and reduce the dose of radiation in pediatrics.

The study, conducted in 2016, was based on age in proportion to weight after dividing pediatrics into age categories .The performance of the imaging procedures used was evaluated by the radiologist when evaluating the pediatric imaging. The type and generation of CT scan devices on which the study was conducted have not been clarified (Bibbo et al., 2016).

Supervised a retrospective study to establish National Diagnostic Reference Levels (DRLs) in Egypt for computed tomography (CT) on 3762 patients who underwent head, chest (high-resolution), abdomen, pelvis, chest, abdomen, pelvis, and CT ligature scans (aorta and lower extremities) at 50 CT facilities. (Salama et al., 2017).

The Egyptian DR finding, for high-resolution chest CT, abdominal and pelvic DRLs are higher than others but are similar to others for DLP in the chest. While the abdominal and pelvic DRLs are higher than in other nations, the abdomen DRLs are lower than those in Japan and higher than those in the UK. The study revealed the need for better education of CT personnel on aspects affecting image quality, dose management, and protocol optimization. (Bolowia, 2018) A study conducted in Uganda aims to determine the radiation doses administered to pediatric patients during computed tomography (CT) scans to suggest diagnostic reference levels (DRLs). Five CT scanners in 2019 and 2020 collected data on patients, protocols, and CT regimens for 684 patients. For the head, chest, and abdomen protocols, the dose was calculated in four age groups: 0–1 year, 1–5 years, 5–10 years, and 10–15 years. Compared with IAEC and DRLs in Japan, the 75 percentile of CTDI vol and DLP were considered as DRLs. There was a significant difference between the head CT dosages and the reported DRLs in Japan and the IAEC.

(International Atomic Energy Commission). The DRLs that were set for heads were higher than those that were offered in other nations. Longer scan lengths, greater mA, and lower pitch values were the causes of the higher DRLs.

A study was conducted in Jordan (Rawashda et al., 2019) this study aimed to measure and analyze values (DRL) for Pediatric CT in Jordan .The dosage information for four common CT scans ,brain, chest, abdomen, and pelvis performed at imaging facilities and hospitals (n = 4) were measured. Within the various hospitals and age categories (1 year, 1-4 years, 5-10 years, and 11-18 years), the values of the volume CT dose index (CTDI vol) and dose length product (DLP) were compared. Jordanian DRLs were contrasted with international DRLs.

The DRLs for each CT scanner varied significantly, with up to a four-fold variability in dose between hospitals.

The CTDI vol and DLP values of pediatric CT scans in Jordan varied, according to this study's findings. The values in Jordan were comparable to those in other nations for CTDI vol though. The results showed that the values of DLP in Jordan and other countries were very different. It was relatively high these differences were a result of different CT scan devices and protocols. The weight of the patients in this study was not taken into account, and the generations of CT imaging devices were not indicated, nor was it clarified whether a calibration was made for these devices.

The results were limited to the fact that the discrepancy in DLP values was due to changes in mAs, pitch, slice thickness, and kVp factors.

A study was conducted on 705 children of average age (< 3 months -7 years) to evaluate the relationship between patient age and radiation doses related to pediatric head CT using automatic tube selection and existing tube modification methods. The test was

performed on multidetector-row CTs (64–128 slices, Siemens) using automatic tube potential selection and current tube modulation techniques values were calculated CTDI vol and DLP then data were analyzed using linear correlation and analysis of variance. There is a linear correlation between radiation doses and patient age ($R2 = 0.66$, $p < 0.001$) Radiation doses for head CT change linearly with children's age.

Despite lower CTDI vol and DLP for most children, longer scan lengths resulted in higher DLP for some pediatric head CT. When automatic tube potential selection and automatic tube current modulation procedures are applied to the more sophisticated CT scanners included in the study, pediatric head CT dosages vary linearly with patient age. Although most pediatric head CTs in the study had lower CTDI vol than EDRLs, due to longer scan times, DLP for more than a quarter of the tests was greater than similar European DRLs (Kharita et al., 2020).

Where Automatic tube potential selection (ATPS) and (ATCM) automatic tube current modulation approaches assist in adjusting radiation exposure to changes in patient age-related attenuation, skull thickness, and/or head size.

In Iran, research on CTDI vol and LDRL was done. The modified quality control-based (MQC) technique was used to gather the data. For local and governmental DRL assessments of the head, paranasal sinuses, chest, and abdomen scanning method (QC) was employed in a trial that consisted of four CT scans. Not collecting data method. Because the study was based on quality control and did not include the imaging data of the CT system at the end of the examination when imaging the patients, it does not reflect the true values of CTDI vol and DLP, and this study did not rely on the dose report is one of its drawbacks. When imaging people, the computed tomography machines' output was based on simulation, nonetheless. A 16 and 32-cm phantom was used in the investigation.

The main goals of this study were to regulate kVp and the current tube (Dose, 2021).

A Pediatric Diagnostic Regulatory Reference Level (DRL) was established in Cameroon and compared to levels found in France. The acquisition was between the three hospitals' 75th percentile dose parameter values and the diagnostic reference level (DRL) in France A total of 320 patients from three medical facilities who had undergone at least one cranial CT scan were included in this retrospective and evaluative multicenter investigation. The CT acquisition parameters, such as the volume CT dose index (CTDI vol), tube potential (kV), tube current (mA), slice thickness (T), spiral or sequential scanning procedures, and dose length product (DLP), higher than values of France's DRL, respectively. The study revealed a considerable dosimetry overshoot (Eddy et al., 2021). In the current study, the absorbed dose was evaluated from the CT dose index (CTDI vol) and the dose length product (DLP) for the head, chest, and pelvis for children under the age of 15 who were admitted to an Iran hospital. A pencil ionization chamber was used to measure the values of CTDI vol and DLP.

CTDI vol & DLP values for the head, chest, and pelvis were significantly different.

There was a noticeable difference in mean values of CTDI and DLP. According to monthly head CT scans. According to the results, the DLP and CTDI vol values were lower than those suggested by the European Committee standards and earlier research from other findings (Hanafi et al., 2021).

(Abdul Qader et al., 2021) has in a previous study evaluated CTDI vol and DLP in computed tomography, intimate (CT) to suggest national diagnostic reference values (N DRLs).

Results indicating higher than global values, circumferential mass made up of the head, caudal, abdominal, and pelvic components as calculated gravity were her values 2.75 (head), 10.29 (chest), 22.29 mSv (abdomen).

According to a survey, there were 175 CT centers in Nigeria as of June 2017, and 57 of them had malfunctioning equipment at the time of the survey. Only 36 of the centers invited to the study provided information on dosing. Others did not keep electronic copies of patient and dose information. It was the bulk of the CT system 13 (4-64) slides). (Philips, Toshiba, GE, and Neusoft) The oldest and newest CT installations were produced in 2007 and 2015, respectively, with the oldest and newest installations occurring in 2008 and 2016. The devices were not as recent as MDCT.

(Ploussi et al., 2020). They studied radiation dose indices in computed tomography (CT) improvements in DLP values in the largest children's hospital in Greece. Age- and weight-based LDRLs for pediatric CT scans were established. There were 756 pediatric patients with head, chest, and abdomen-pelvis CT scans. Age groupings for patients were assigned based on hospital protocols. LDRLs were calculated using the CTDI vol and DLP 75th percentiles. After that, the values of the LDRLs were reorganized into weight categories and compared to the European DRLs. For head CT exams, DLP LDRLs were greater than European DRLs, whereas, for body CT exams, they were lower.

(Muhammad et al., 2020) In a retrospective study, CTDI vol and DLP indicators were studied for pediatric brain CT scans to improve reporting DRLs. and to set local DRLs for pediatric CT.

A retrospective analysis was performed on 1192 pediatric patients who underwent CT brain, CT thorax, and CT chest-abdomen-pelvis (CAP) exams. The patients were

divided into four age groups. (0–1), group 2 (1–5), group 3 (5–10), and group 4 (10–15) are the age groups. DRLs for each age group set at the 50 percentile were generated, along with statistics for each group such as the volume-weighted CT dose index (CTDI vol), dose-length product (DLP), and effective dose. Between age groups, there were significant differences in CT dose and image noise levels with p-values of 0.05. The results of a CT brain scan revealed the highest CTDI vol and DLP values across all age groups with the lowest noise index value obtained in the 10-15 age group. To evaluate the image quality index.

The noise value was objectively measured in this study using specific software by measuring the photons in each Hounsfield unit, as it was defined for each pixel in the images of the pelvis, abdomen, and brain. To accurately assess the picture quality for this investigation, a radiologist and radiology technician must be present, and it may be necessary to consult a medical physicist to determine the noise level.

(Inoue et al., 2022). in a study of their diagnostic reference levels for pediatric brain computed tomography (DRLs) for an age-based cohort and considering how continuous factors of age and weight affect radiation dose indices (CT dose index and dose length product) in CT scans of the pediatric brain. A total of 980 tomographic images of the juvenile brain were examined in a retrospective investigation. Plots of CT dose indices against age and weight were fitted using the curves and equations were derived to predict age and weight-dependent standardized dose indices. Were used and errors were calculated the outcomes revealed a quick initial increase and a following moderate increase in dosage indices with increasing age and weight. According to the error analysis of this study, DLP indices by weight can be examined more accurately and better than pediatric age.

Curve fit the relationship between CT dose indices and age or weight as continuous variables facilitate identification of standard dose indices in pediatric brain CT scan by weighing, we can estimate the DLP and CTDI vol more accurate values compared to age if pediatrics weights are taken and not just estimates. This study was about estimating the parameters of the standard dose when imaging pediatric brains based on the patients' weights according to age estimates. This caused larger ages-based estimation differences in errors in DLP and CTDI vol.

(Tan et al., 2021). Researchers analyzed the DLP and CTDI vol from CT brain scans performed in pediatric and adult emergency departments (EDs) to ascertain the percentage of scans that were carried out within the reference ranges advised by the International Commission on Radiological Protection (ICRP). Four hundred and seventy-nine brain computed tomography studies have been performed in pediatrics.

Using conversion factors, known as k-coefficients, which were obtained using a 16 cm head CT dose phantom, the effective dose was then computed from DLP.

Average effective dose estimates were generally higher in pediatric brains compared to general emergency departments as for the conclusions:

Radiation doses from brain CT studies were significantly higher in generalized ED cases and less than half as high as the studies were within the reference levels recommended by the ICRP. The study was conducted in Singapore and was conducted in a single healthcare network of Pediatric ED and three general EDs.A limitation of this study did not refer to the generations of the CT scan and to the parameters used when examining in addition to neglecting the weight of the patients in this study.

This study included estimation of ionizing radiation exposure doses, creation of local DRLs for CT scans based on age, comparison of local DRLs with national and European

DRLs as well as literature data from other countries to regulate and reduce radiation exposure patients receive during radiotherapy.

In 2019, 194 CT scans of the head were performed, and the results showed. The median DLP values for head CT for age groups of > 1, <1-5, <5-10, <10-15, and < 15–18 years were 144.3, 233.7, 246.4, 288.9, respectively 315.5. The estimated local DRLs for head CT exams are 170, 300, 310, 320, and 360 mGy*cm, respectively, and 130, 210, 275, and 320 mGy*cm for age groups of (0–3 months, 3 months–1 year, 1–6 years, and 6 years), respectively.

The findings of this study demonstrated that settled new LDRLs of brain CT examinations were 2-4 times lower than national DRLs and around 2 times lower than European DRLs. Additionally, the study found that compared to the majority of published data from other institutions over the previous six years, pediatric head CT doses are much lower. Like other studies, this study was based only on age groups and did not depend on estimating values of pediatric.

Weights it did not also describe generations of CT scans. It was not specified if these tests were without contrast media or not (Gricienė and Šiukšterytė, 2021).

UK national DRLs have been up dated to perform computed tomography examinations on the head and chest pediatrician this study the techniques recommended by the International Committee for Radiation Protection were used. Pediatric CT scans of the head, chest, abdomen/pelvis, and cervical spine were the target of a nationwide dose audit in the UK in 2019. Post-examination dosimetry (CT dose-volume index and dose-length product) and patient weight (for body scans) were the primary areas of the initial review.

According to the analysis of the data provided it was appropriate to propose

national DRLs for CT head examinations in the 0-to-1, 1-5, 5-10, and 10-15 age groups. The current values are revised downward and the number of age groups for national DRL listings is increasing.

National DRLs for weight ranges 5–15, 15–30, 30–50, and 50–80 kg have also been proposed for chest CT scans for the first time in the United Kingdom. For cervical spine or abdominal/pelvic examinations. Among, the main recommendations for improvement are the use of tube current modulation (mA), iterative reconstruction, and test tube voltage selection (kVp). In this study, the national DRLs for pediatric chest examinations were based on patient weight ranges. A limitation of this study was that there was not enough data collected, especially about weight, to recommend national DRLs. In addition, not enough information has been collected to recommend national DRLs for assessment of the cervical spine, abdomen, and pelvis (Worrall et al., 2022).

2.3 Routine Pediatric Head (Brain)

Some CT makers have created cutting-edge features, especially for pediatric applications.

The 2008 scale factors were created to deliver an average dosage to pediatric heads' soft tissues that is equivalent to the facility's average dose to an adult head's soft tissues.

On the Image Gently website, the tables from the Pediatric Radiology manuscript are available.

The CTDI v for a head exam on a one-year-old child is less than 35 mGy according to the 2014 scale parameters. For head exams, there are only five patient sizes used. A one-year-old's and a five-year-old's head sizes are roughly 80% and 90% of an

adult's, respectively. The information in Strauss' paper explains how to develop suitable pediatric CT protocols for various.

State-of-the-art The two-dose indices that are generally shown by CT scanners are the CT dose index (CTDI (vol) [mGy]) and dose length product (DLP [mGy-cm]), both of which are based on one of the two standard CTDI phantoms (16- or 32-cm diameter) that are used to calculate CTDI (vol). The CT scanner's radiation output is shown as CTDI (vol), not the radiation exposure a particular patient would receive. Because of this discrepancy, pediatric radiologists have asked for a way to calculate the CT patient dose depending on the size (weight) of a child or a tiny adult.

To provide a more accurate estimate of CT patient dose, we were able to describe the technique created by the American Association of Physicists in Medicine (AAPM) Task Group 204. Radiologists now have a useful tool to help them better regulate the radiation dose that their patients receive thanks to these improved patient dose estimations. As shown in the table (AAPM, 2015).

Table 2.1: Pediatric Head – Routine (Helical) (Selected PHILIPS Scanners). (AAPM, 2015)

PHILIPS	Brilliance 16 slice	Brilliance 64 channel	Ingenuity CT	Brilliance iCT SP	Brilliance iCT
Scan Type	Helical	Helical	Helical	Helical	Helical
Rotation Time (s)	0.5	0.4/0.5*	0.4/0.5*	0.4	0.4
Collimation	16 × 0.75 mm	64 × 0.625 mm	64 × 0.625 mm	64 × 0.625 mm	64 × 0.625 mm
kV	100	100	100	100	100
Manual mAs/slice approach	0-1yr: 215 1-2yrs: 260 2-6yrs: 340 6-16yrs: 440 16+yrs: 560	0-1yr: 240 1-2yrs: 300 2-6yrs: 400 6-16yrs: 500 16+yrs: 640	0-1yr: 240 1-2yrs: 300 2-6yrs: 400 6-16yrs: 500 16+yrs: 640	0-1yr: 240 1-2yrs: 300 2-6yrs: 400 6-16yrs: 500 16+yrs: 640	0-1yr: 240 1-2yrs: 300 2-6yrs: 400 6-16yrs: 500 16+yrs: 640
AEC approach	N/A	N/A	Infant DRI = 34 Child DRI = 37	Infant DRI = 34 Child DRI = 37	Infant DRI = 34 Child DRI = 37
Pitch	0.5	0.4	0.4	0.4	0.4
FOV (mm)	250	250	250	250	250
CTDI-vol (mGy)	0-1yr: 18.1 1-2yrs: 21.9 2-6yrs: 28.6 6-16yrs: 37.0 16+yrs: 47.1	0-1yr: 18.9 1-2yrs: 23.6 2-6yrs: 31.5 6-16yrs: 39.4 16+yrs: 50.4	0-1yr: 18.9 1-2yrs: 23.6 2-6yrs: 31.5 6-16yrs: 39.4 16+yrs: 50.4	0-1yr: 20.2 1-2yrs: 25.3 2-6yrs: 33.7 6-16yrs: 42.1 16+yrs: 53.9	0-1yr: 20.2 1-2yrs: 25.3 2-6yrs: 33.7 6-16yrs: 42.1 16+yrs: 53.9
RECON 1					
Type	Axial	Axial	Axial	Axial	Axial
Reconstruction Filter	HR / UB	HR / UB	HR / UB	HR / UB	HR / UB
Thickness (mm)	5	5	5	5	5
Increment (mm)	5	5	5	5	5
RECON 2					
Type	Axial	Axial	Axial	Axial	Axial
Reconstruction Filter	YD	YD	YD	YD	YD
Thickness (mm)	1	0.9	0.9	0.9	0.9
Increment (mm)	0.5	0.45	0.45	0.45	0.45

*Shorter rotation times should be considered if the required tube current-time product (mAs) can be reached.

2.4 Radiation Protection

Radiation protection is an idea that includes the requirements, technologies, and processes associated with protecting everyone from the harmful effects of ionizing radiation, including radiation workers, members of the public, patients receiving diagnostics, and medical radiation therapy (Do, 2016). The use of X-rays for medical diagnostics marked the beginning of the appreciation of the advantages of radiation. On the other hand, even at modest doses of radiation, harmful radiation effects including radiation-induced cancer should be a concern. Although this danger cannot be eliminated, it can be minimized. As a result, one of the key aspects of radiation protection now involves openly balancing the advantages of nuclear and radiological practices with the risk of radiation exposure and efforts to reduce residual risks. The environment contains both radioactive and ionizing radiation as natural and permanent elements. The use of artificial radiation, the ionization process, and these sources of so-called natural background radiation all affect atoms and molecules at least shortly and may harm cells (ICRP, 2017).

It may be impossible for a cell to survive or reproduce if cellular damage occurs and is not properly healed. The ICRP Protection has proposed a system.
Justification, optimization, and individual dose reduction are the three pillars of radiation protection. According to the principle of justification (Brady, Cain, and Johnston, 2012). (The exposure the radiation should be beneficial) (World Health Organization, 2016).

This means that one must obtain sufficient individual or community benefit to balance the harm caused when a new radiation source is added, existing exposure is reduced, or the risk of potential exposure is reduced. The concept of maximizing protection states that, taking into account socio-economic considerations, the probability

of exposure, the number of people exposed, and the volume of their doses should be kept as low as practically possible (ALARA). The general rule for the application of dose limits is that they should not be exceeded in cases of planned exposure other than those involving the exposure of patients to regulated sources for medical purposes.

2.5 Image Quality

Achieving picture quality that is sufficient for the clinical goal is the top priority for every diagnostic imaging test to ensure that the clinical purpose is not jeopardized and that the necessary diagnostic information is provided by the images from the entire procedure. It has been assumed that the pooling of data on DRL amounts offers information on the quantity of radiation that the majority of radiologists agree will provide images that are sufficient for clinical purposes as data from patient surveys are collected from clinical sites. Without considering requirements for image quality, a sole concentration on DRL volumes could eventually drive down the value of the DRL and damage image quality.

When altering imaging techniques, it is crucial to make sure that image quality appropriate for the diagnostic goal was attained. Radiation levels that are too high or too low are both unsatisfactory. Radiation levels that are too low result in poor image quality. When the image quality is insufficient for the clinical goal, the examination must be repeated, exposing the patient to extra radiation, and there is no clinical benefit from the radiation. Optimizing must strike a balance between patient dose and image quality as radiation levels decrease, the required degree of image quality must be kept before gathering DRL data, and surveyors should confirm that imaging equipment is operating

in a satisfactory manner using a suitable QC program, when possible, evidence-based standards for evaluating image quality should be used (Vañó et al., 2015).

2.6 Considerations for DRL Surveys in Pediatric CT SCAN

Setting DRLs involves several different factors, including patient choice, with CT; patient size is a key factor in determining the quantity of radiation needed to provide an appropriate image for a particular procedure. Either a patient thickness range (typically specified as a weight range) or the use of extensive electronic patient data from PACS systems are options (Samei et al., 2014).

The organization setting the DRL will determine the specific amount to be used in its development. It would be wise to consider the quantity used in other literature and the published DRL values though. This should be taken into account as an additional improvement when determining pediatric DRL values (Morin et al., 2011). The examination as a whole (all scan sequences), as well as each sequence (such as non-contrast-enhanced, contrast-enhanced, and delayed), must be taken into account while performing CT optimization. Since this provides a good depiction of the whole amount of ionizing radiation used during the examination, the cumulative DLP for the entire examination is the DLP quantity that is used. The number of patients needed to evaluate DLP at least 20-30, when there are fewer it would be best to record information about patient sizes or at the very least limit the range of sizes (Roch et al., 2013).

2.7 Relationship between Patient Weight and Age in DLP and CTDIv

Group classifications were typically based on patient weights.

Nevertheless, the majority of the publications solely focused on age groups in their research. This was caused by the challenges in getting patients' weights during the CT scan process, as well as the fact that weight in general does not correlate well with age in each particular patient. Therefore, the compatibility of the patient age groups and average weights was essential to the success of our investigation. In research done by (Vassileva, 2019). he balanced the kids' ages and weights based on dividing them into four age groups

Therefore, that he could calculate the size of the CT dosage index and the product's length. As shown in Figure 2.1

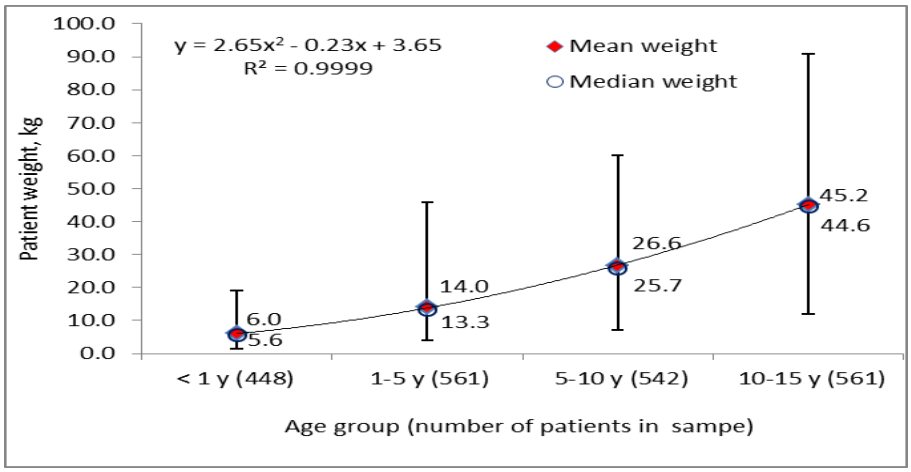


Figure 2.1: Relationship Between Pediatric Age and Weight (Vassileva, 2019).

Additionally, he grouped ages by weight according to the most prevalent age bracket utilized for Diagnostic Reference Levels or an equivalent. Shown as in Table Table 2.2

Table 2.2: Weight Grouping for Pediatric DRLs (Vassileva, 2019)

Description	Weight group	Age group based on weight-for-age charts	Most common age groups used for the NDRLs (or equivalent)
Neonate	< 5 kg	< 1 m	0 y
Infant, toddler and early childhood	5 - < 15 kg	1 m - < 4 y	1 y
Middle childhood	15 - < 30 kg	4 - < 10 y	5 y
Early adolescence	30 - < 50 kg	10 – < 14 y	10 y
Late adolescence	50 - < 80 kg	14 - < 18 y	15 y

2.8 CT Dose Parameter (CT scan parameters)

2.8.1 The Main Dose Measurements for Computed Tomography are:

CTDI vol, DLP, Effective dose (DE), Multiple-Scan Average Dose (MSAD), and CTD index, such as volumetric CTDI (CTDI vol and its unit mGy) and dose length product (DLP) are used to calculate DRLs and LDRLs for CT scans.

2.8.1.1 Multiple-Scan Average Dose

The average dose is at the center of a sequence of scans, specifically at the center of the rotational axis of a CT imaging system. As shown in Fig 2.2. The MSAD was the first CT dose descriptor to be identified. Eq 2.1

Eq 2.1: MSAD= CTDI x **SW/BI**

Where MSAD is Multiple-Scan Average Dose ,CTDI is the CT dose index, SW is slice thickness in millimeters and BI is bed index or slice spacing (Ewaidat, 2013).

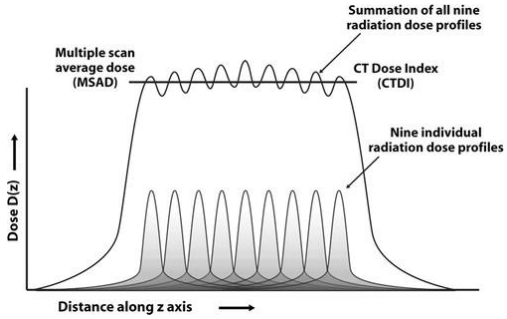


Figure 2.2:(Multiple-Scan Average Dose) (Bauhs *et al.*, 2008).

2.8.1.2 CT Dose Index (CTDI).

► Computed Tomography Dose Index, CTDI is the primary dose measurement concept in CT. The CTDI was the next CT dose descriptor after MSAD. The U.S. Food and Drug Administration (FDA) developed CTDI FDA. The CTDI FDA represents the mean absorbed dosage in the scanned object volume. The unit of the CTDI is Gray (mGy). In addition, The CTDI FDA is obtained by dividing this area by the number of slices times the slice width [(n) (SW)]. (IAEA TECREPO-5, 2011)

$$CTDI_{FDA} = \frac{I}{n.SW} \int_{-7}^{+7} D(z)\, dz$$

Introduction of the (CTDI w) in the patient's x-y axis rather than the z-axis for the average dose. (McCollough et al., 2008).

$$CTDI_{weighting} = \tfrac{1}{3} CTDI_{100,\,centre} + \tfrac{2}{3} CTDI_{100\,peripheral}$$

The CTDIv is to consider the dose in the z-axis, which can be calculated with the following relationship for spiral/helical CT imaging. As shown in Fig 2.3 .

$CTDI_{vol} = CTDI_{weighting} / Pitch$

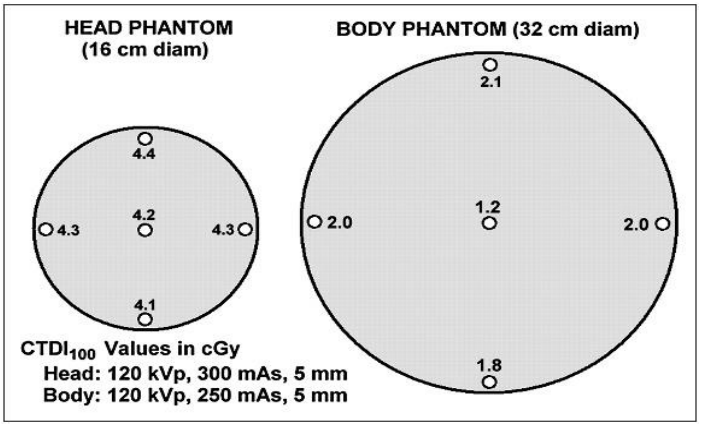


Figure 2.3: Head and Body CT Phantom(Goldman, 2007)

2.8.1.3 Dose Length Product

A variable that serves as a proxy for the energy that the patient receives during an L-length computed tomography scan.DLP (mGy.cm). The DLP gives an estimate of the total exposure for several scans. These are shown on the dose report that is displayed on the CT scanner console. The DLP can be calculated if the length of the irradiated volume (scan length) and the CTDIv are known.

The DLP can be calculated by **CTDI vol (mGy) X scan length (cm).** Figure 2.4

CTDIv is not dependent on the scan length. The DLP is directionally proportional to the scan length. DLP is expressed in mGy-cm. The scan length has a direct relationship with the DLP.

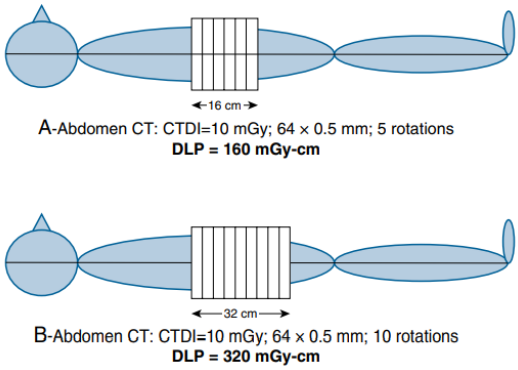


Figure 2.4: (Relationship of DLP with Scan Length) (Cunningham et al., 2017).

2.8.1.4 Effective Dose (DE)

The effective dose is used to compare the stochastic risk of non-uniform radiation exposure. It is thought to be the most effective technique for estimating stochastic radiation risk. (Goldman, 2007). It is crucial to understand that the potential biological consequences of radiation depend not only on the radiation dose received by a tissue or organ but also on how sensitive that tissue or organ is to radiation on a biological level. The biological effect (harm) that a 100-mGy dosage to extremities might have is different from a 100-mGy dose to the pelvis (Sowby, 1981).

This variation in biological sensitivity is reflected in the dose descriptor known as effective dos. Different tissues have different radio sensitivities and the absorbed dose to specific organs.

The calculated absorbed dose is approximate because it varies on the body's size and weight, disease, age, gender, nutrition, and drug (Hendrick et al., 2010).

Eq 2.2: DE = ΣT (wT*wR*DT. R) ⇨ **(E = ΣwT * HT)**

- wT= tissue weighting factor (next page)
- wR= radiation weighting coefficient (1 for photons)
- DT. R average absorbed dose to tissue T.
- DE units are SI - Sieverts (Sv); international unit) and (rem, U.S. unit).
- 1 rem = 10 mSv; 1 Sv = 100 rem
- HT = The Equivalent Dose (Dose Average energy absorbed by organ).

Several ICRP publications include a list of the tissue weighting parameters.

As shown as in Table 2.3 (Tsapaki *et al.*, 2021).

Table 2.3: The Risk Variables Based on the ICRP's Actual Determination

Tissue	Tissue weighting factor, wT	ΣwT
Bone-marrow (red), colon, lung, stomach, breast, remaining tissues(*)	0.12	0.72
Gonads	0.08	0.08
Bladder, oesophagus, liver, thyroid	0.04	0.16
Bone surface, brain, salivary glands, skin	0.01	0.04
	Total	1.00

(*) Remaining tissues: Adrenals, extrathoracic region, gall bladder, heart, kidneys, lymphatic nodes, muscle, oral mucosa, pancreas, prostate (♂), small intestine, spleen, thymus, uterus/cervix (♀)

The effective dose is shifted for patients undergoing computed tomography

To Calculate Values by which the full radiation dose to which the patient is exposed during CT scan is known using the dose-length product (DLP) with an effective dose conversion factor (K).

K-factor. The proportionality constant between the effective dose and the DLP

Knowing the K value enables the calculation of the ED as follows:

Eq 2.3: DE (mSv=) k * DLP. K value its unit mSv/mGy.com

DLP = CTDI vol (mGy) * scan length (cm).

DE = K* $CTDI_V$ * scan length

Table 2.4: (Conversion Factor for Some Organ) (Nagayama et al., 2018)

ED = K x DLP (Conversion Factor)				
	0 year	**1 year**	**5 years**	**10-15 year**
HEAD	0.00011	0.0067	0.0040	0.0032
NECK	0.017	0.012	0.011	0.0079
CHEST	0.039	0.026	0.018	0.013
ABDOMEN/PELVIS	0.049	0.030	0.02	0.015

Factors Affecting Dose in CT scan

The factors that can be affected by CT scan be classified into direct effects on the dose (factors that increase or decrease the dose to the patient and are under the direct control of the technologist). Indirect effect on the dose **(**have a direct influence on image quality, but no direct effect on radiation dose).

2.8.2 Exposure Technique Factors (DIRECT)

2.8.2.1 Milliamperage-Seconds

mAs refers to the number of photons that can exposed to the patient during image scanning which affect the patient's dose directly and can measure its effect on the patient's dose while keeping all other technical factors constant.

mAs are directly proportional to radiation dose. As shown in Table 2.5.

Table 2.5: Changes in CTDI in a 32 cm Diameter Body Phantom as a Function of mAs for Both Constant Rotation Time Settings and Constant Current Settings (Romans, 2018).

Tube Current (mA)	Rotation Times(s)	Tube Current Time Product(mAs)	CTDI w (mGy)	CTDI w/mAs (mGy/mAs)	%CTDI w/mAs Difference 220 mAs
220	0.5	110	7.4	0.068	0.0
440	0.5	220	15	0.068	-
580	0.5	290	19.8	0.069	+1.5
440	0.33	1459	0.940	0.068	0.0
440	0.375	165	11.3	0.068	0.0
440	1.0	440	30.2	0.069	+1.5

2.8.2.2 Effective Milliamp Rage-Seconds.

Milliampere second (mAs) is created using the two parameters milliamperes (mA) and time (s). (Signal-to-noise ratio) SNR is raised, image noise is reduced, and patient exposure is increased by increasing the tube current and scan duration (mAs) product. There is a nearly linear relationship between tube current and patient dose, with increases in mAs leading to increases in patient dose (Cunningham et al., 2017).

The mAs per slice are referred to as the effective mAs in multislice CT scanners.

Effective mAs or mAs per slice True mAs/ pitch**. (**On MSCT, mAs is often adjusted to keep effective mAs), Increasing the pitch from one to two increases the mAs per rotation from 100 to 200.

2.8.2.3 Kilo Voltage Peak (kVp).

The radiographer can modify the tube voltage using CT scanners. Kilovolt peak, or (kVp), settings are what are used in these situations. Choices for kVp are more constrained when compared to mA options. Enhancing the thick section penetration of the kVp beam. Regular body CTs for adult patients are often performed with 120 to 140 kV. To improve image quality and lower patient dose, the right choice of mAs and kVp is essential.

The patient's radiation dose is decreased by the mAs reduction while maintaining the kVp. If the kVp is decreased while the mAs are maintained, the patient's radiation dose also lowers. (Bushberg et al., 2012).

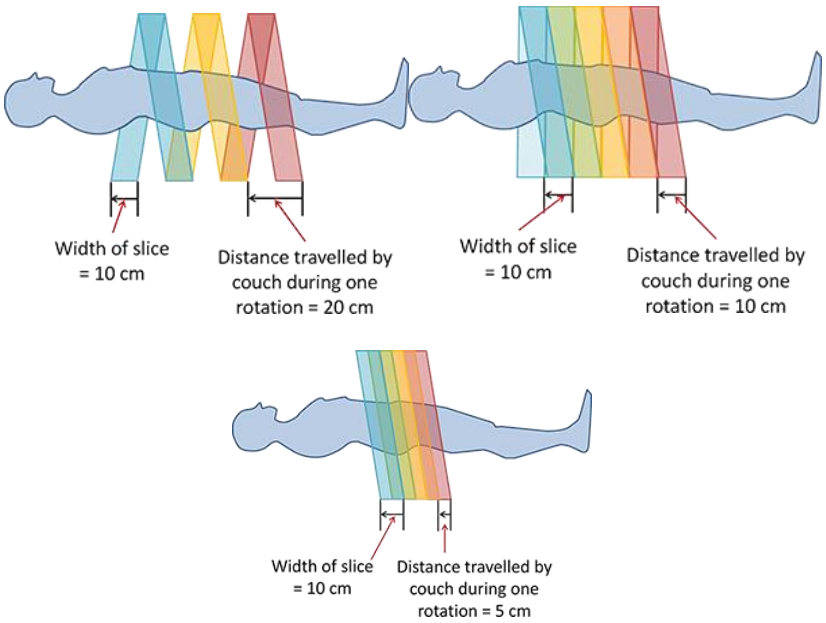
The radiation dose is proportional to the square of the kVp) if the KVp increases the dose increases. Shown in Table 2.6.

Table 2.6: (Changes in CTDI $_{weighting}$ in a 32-cm Diameter Body Phantom as a Function of Tube Potential (KV) (Romans, 2018).

Peak Voltage (kVp)	CTDI w (mGy)	CTDI w/mAs(mGy/mAs)	% Difference from 120-kVp Setting
80	18	0.073	-63.6
100	32.3	0.131	-34.6
120	49.4	0.200	-
140	68.2	0.276	+38.2

2.8.3 Pitch:

The relationship between the absorbed dose and pitch have a directly proportional to mAs/pitch. If the pitch increases by two the dose will be reduced to one-half (Tsalafoutas et al., 2011). If the pitch changes from one to two the CTDI v decreases from 1.0 to 0.5 mGy. As shown in Figure 2.5



Pitch = 20/10=2 Pitch = 10/10=1 Pitch = 5/10=0.5

Figure 2.5: (pitch relationship with width of slice and distance traveled) (Yaffe, 1984).

All the CT dose parameters can be summarized in Table 2.7 (Cunningham et al., 2017).

Table 2.7: A Summary of Important CT Dose Parameters.

Dose Parameter	Definition	Effects on Radiation Dose	Unite
Tube Potential or voltage.	X-ray beam energy	Proportional to square of tube voltage change.	kVp
Product of tube current and time	Photon flounce: the number of photons in a defined exposure time.	Direction is proportional to radiation dose.	mAs
Pitch	The ratio of table feed per gantry rotation.	Inversely proportional to radiation dose.	mGy
CTDI w	Average radiation dose in scan volume measured in standard CT phantoms: 1/3 CTDI center + 2/3 CTDI periphery	Directly proportional dose in unit volume, influenced by pitch factor.	mGy
DLP	CTDI vol x scan length(cm)	Directly proportional to total scanned radiation dose.	mGy-cm
Effective Dose	Overall risk-related radiation exposure: ΣWt (tissue weighting factor) x Ht (tissue equivalent factor)	Directly proportional to total scanned radiation dose and overall risk of irradiated tissue.	mSv

2.9 Number of Detectors

The radiation dose is inversely proportional to the number of detector rows. There is a tendency for the dose to decrease as detector row counts rise from four to eight to 16 rows (Moore et al., 2006).

2.10 Over-Ranging (Over-scanning)

At the beginning and the end of a spiral CT scan with multi-row detectors, the patient was exposed outside the imaging range (Li et al., 2007).

2.11 Patient Centring

The patient must be centered in the gantry isocenter for accurate imaging of the anatomy.

Inaccurate Patient cantering (miscentering) degrades the image quality and increases the dose to the patient, especially with the use of Automatic exposure control (AEC) in CT. As shown in Fig 2.6

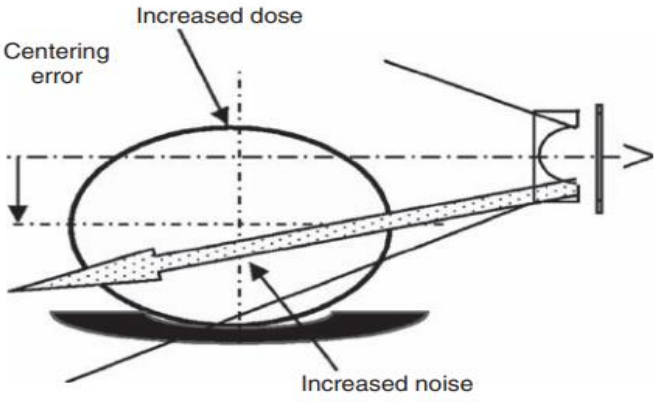


Figure 2.6: (Gantry Isocenter) (Cunningham et al., 2017)

For a 32-cm CTDI body phantom, a miscentering of about three cm and six cm can result in an increase in doses by 18% and 41%, respectively. Miscentering in elevation by 20 mm to 60 mm with a mean position 23 mm below the isocenter can result in a dose increase of up to 140%. With a 33% mean dosage penalty, assuming that the tube current is increased to make up for the noise that miscentering has caused to increase.

2.12 The Dose Reference Levels (DRLs)

The (ICRP) introduced "diagnostic radiation protection" in 1990. (DRL) to persuade authorities, government organizations, and healthcare facilities to produce radiation exposure safety guidelines that follow clinical aims. DRLs are intended to serve as a local institute's safety reference for radioactive processes (Vañó *et al.*, 2017).

Since the ICRP initially established the national dose distribution in 1996, the DRL has been suggested as the 75 percentile (third quartile).

When DRLs are derived, a hospital or medical institution can regulate the use of radiological techniques in a way that meets patient requirements, prevents unwanted exposure, and maintains image quality. A (DRL) is a quantity that is defined for a certain imaging process and is used to help reduce radiation exposure. DRLs are no limits and are not meant to be applied to patient exposures.

The median DLP for all pediatric single non-contrast head CT exams was 543 mGy cm (IQR 357-758 mGy cm), with a difference between the 25 and 75 percentiles of about 112% (Sadigh *et al.*, 2018).

2.12.1 Use of DRL to Reduce Patient Dose

Many professionals support the use of diagnostic reference levels as a crucial dose optimization tool. and oversight agencies, such as the International Atomic Energy Agency, the American College of Radiology, the American Association of Physicists in Medicine, the United Kingdom Health Protection Agency, International Atomic Energy Agency (IAEA), and the European Commission (EC).

DRLs are frequently established at the 75 percentile of the dose distribution using surveys conducted over a sizable user base (i.e., large and small facilities, public and private,

hospital and outpatient), using a particular dose-measuring technology and phantom measurements (Cho, 2020).

DRL values typically represent the 75 percentile in the US of clinically applicable dose indices for a standard patient size from a regional or national sample because obesity affects a third of the population (AAPM, 2011).

They are established both locally and nationally, and there are significant differences between both regions and nations. To develop fresh reference values that can show changes in the mean and standard deviation of the dose distribution, dosage surveys should be repeated regularly.

The use of diagnostic reference values has been shown to reduce the overall dose and the range of doses seen in clinical practice. for instance, normal radiography doses were shown to have decreased by 30% between 1984 and 1995 and by an average of roughly 50% between 1985 and 2000 according to U.K. national dose studies, while these dosage reductions might be a result of increased equipment dose efficiency, investigations that are started when a reference dose is surpassed frequently lead to the identification of dose reduction techniques that don't degrade the general standard of the particular diagnostic test. The result is a narrower dose distribution and a lower mean dosage when data points above the 75 percentile.

2.12.2 CT DRLs from Other Countries:

DR levels must be specified using procedure parameters that correspond to those employed in a site's clinical practice and a readily and consistently measurable dosage metric. Table 2.8 and Table 2.9.

CT diagnostic reference levels employment CTDI-based metrics such CTDI weighting, CTDI vol, and DLP. You can utilize CTDI values that have been normalized (CTDI per mAs) by multiplying them by the usual method factors, or can be measuring CTDI values using the usual clinical technique factors. As shown in Table 2.8., 2.9, 2.10.

Table 2.8: Adult DRLs for CTDI $_{v}$ (mGy) & DLP (mGy·cm) from Other Countries (Cho, 2020).

	Head		**Abdomen**		**Abdomen & Pelvis**			
	Whole Exam		**Whole Exam**		**Pelvis**		**Whole Exam**	
	CTDIv	**DLP**	**CTDI v**	**DLP**	**CTDI v**	**DLP**	**CTDI v**	**DLP**
EC 1999	60	1050	35	900	-	-	35	780
ACR 2002	60	-	35	-	-	-	-	-
UK 2003	-	930	20	470	-	-	20	560
Germany 2003	60	1050	25	770	-	-	24	1500
Switzerland 2004	60	800	20	710	30	540	-	-
Taiwan 2007	72	850	31	680	28	520	-	-

Table 2.9: Adult DRLs for CTDI v (mGy) & DLP (mGy·cm) (Cho, 2020)

	Head		**Abdomen**		**Abdomen & Pelvis**			
	Whole Exam		**Whole Exam**		**Pelvis**		**Whole Exam**	
	CTDI vol	DLP	CTDI vol	DLP	CTDI vol	DLP	CTDI vol	DLP
Sweden 2002	75	1200	25	-	-	-	-	-
UK 2003	65 - 100	930	14	470	-	-	14	**560**
Netherlands 2008	-	-	-	-	-	-	15	**700**
EC 2004	60	-	25	-	-	-	15	**700**
ACR 2008	75	-	25	-	-	-	-	-

Table 2.10: CTDI vol (mGy) Statistics from the First 3 Years of the ACR CT Accreditation Program (Cho, 2020).

	2002	**2003**	**2004**	**2002**	**2003**	**2004**	**2002**	**2003**	**2004**
	Adult Head			**Adult Abdomen**			**Pediatric Abdomen**		
Mean	66.7	58.5	55.8	18.7	19.2	17.0	17.2	15.9	14.0
Std. Dev.	23.5	17.5	15.7	8.0	8.7	7.6	9.7	8.6	7.0
75 %tile	76.8	63.9	60.0	22.6	23.4	21.1	20.6	20.5	18.4
90 %tile	99.0	82.2	74.0	29.5	30.6	25.8	26.6	25.6	23.4

2.12.3 CT DRLs for Other CT Applications

Reference values for many repeated CT exams are essential to ongoing efforts to optimize dose in CT because CT practice involves many more types of testing than simple head and body examinations. To achieve this goal, the researcher in this study will evaluate the reference values when imaging the brain scans of children in government hospitals and compare them with international values.

2.12.4 Local DRLs

A local DRL (LDRL) is based on the distribution of patient doses from radiology departments in one large healthcare facility or a collection of healthcare facilities, at the third quartile value (the 75 percentile) (Vañó et al., 2015).

So, the 75 percentile was picked. As the fifties, the National DRLs specification, but the 50 percentile is employed to compare the patient dose distributions with the LDRLs that are usually collected from each radiology department.

2.12.5 National DRL

The national DRL (NDRL) is based on the median (50 percentile) and third quartile (75 percentile) values of the distributions of patient doses that were gathered from a representative sample of radiology departments across the nation, for a specific clinical imaging task.

2.12.6 European DRL

The median (50-percentile) value of the distribution of the NDRLs for a certain clinical imaging job serves as the basis for the European DRL (EDRL).

To depict the NDRLs, the median value has been selected, NDRLs, which already represent 75 percentile dose levels, rather than subtracting values from the 75 percentile. Due to the lack of data available for EDRL evaluation, this definition for EDRL has been chosen.

The EDRLs could not be established based on a single survey of a representative sample of facilities selected from European nations. Furthermore, there was insufficient evidence to support weighting national DRL values by population in each participating country to determine the EDRLs.

If the NDRLs are higher than the suggested EDRLs, the causes of the discrepancies should be taken into account. It should be taken into consideration whether fresh surveys are necessary to update the NDRLs, especially if they are not based on recent national patient dosage surveys. Further lowering patient doses, may result in even greater gains (Cho, 2020).

Chapter Three

Methodology

Introduction

This study is a cross-sectional study conducted from 1/12/2022 - 31/2/2023 in nine governmental hospitals in the West Bank. (Ramallah Medical Complex, Martyr Khalil Suleiman Governmental Hospital (Jenin hospital) , Rafidia Hospital, Abu Al-Hassn Governmental Hospital (Yatta hospital) , Al-Hussein Governmental Hospital (Beit Jala hospital) , Darwish Nazzal Governmental Hospital (Qalqilia hospital) , Alia Governmental Hospital or Hebron Governmental Hospital ،Tubas Turkish Governmental Hospital, Martyr Yasser Arafat Governmental Hospital (Salfeet hospital).

These hospitals were chosen because of the large number of patients and the variety of CT scans that are performed daily. During this study, patients' data from 11 ready-made computed tomography (CT) scans were used.

3.1 Study Population

3.1.1 The Study Sample

The study focused on routine CT scans of pediatric brains in all GH_S, except Jericho Hospital, because the patient's dose data report was not available on imaging devices. The study suggested a sample size of all pediatric patients who got a computed tomography (CT) scan of the brain over three months, as the sample size was 2160 patients.

3.1.2 Study Instruments

DLP and dose descriptors (CTDI v) were assessed and computed. Devices for computed tomography in Palestine's West Bank, where the details of these devices are listed in Table 3.1: Another computer software has been used: Microsoft Excel, and SPSS.

Table 3.1 The Names and Abbreviations of the 11 Image Facilities that have CT Scanners in Nine Cities in the West Bank. The CT Dose Descriptors Collected from the Brain CT Imaging of Patients.

NO	Hospital name	CT (Manufacturer)	Number slices	Scanning technology	Abbreviation
1	Alia Governmental Hospital or Hebron Governmental Hospital	Philips, Incisive CT	128	Helical	AGH
2	Al-Hussein Governmental Hospital-Beit Jala hospital	Philips, Brilliance	16	Helical	BGH
3	Martyr Khalil Suleiman Governmental Hospital – Jenin hospital	Revaluation EVO (GE)	128	Helical	JGH
4	Rafidia Hospital -Nablus	Philips, Ingenuity CT	128	Helical	RGH
5	Martyr Yasser Arafat Governmental Hospital - Salfeet hospital	Philips, Ingenuity CT	128	Helical	SGH
6	Tubas Turkish Governmental Hospital	Philips Mx	16	Helical	TGH
7	Darwish Nazzal Governmental Hospital –Qalqilia hospital	Philips, Brilliance	64	Helical	GGH
8	Ramallah Palestine Medical Complex 1(Emergency department)	Philips Brilliance	128	Helical	RMC1
9	Ramallah Palestine Medical Complex 2 (Ramallah sons) section)	Philips Brilliance	64	Helical	RMC2
10	Ramallah Palestine Medical Complex 2(Ramallah sons' section) GE CT scan	Revaluation EVO (GE)	128	Helical	RMC3
11	Abu Al-Hassn Governmental Hospital – Yatta hospital	Revaluation EVO (GE)	128	Helical	YGH

3.2 (CTDIv and DLP) Report

The data in this study were obtained through computerized tomography devices, and the Stradus archiving programs were used, which are available on the computer systems of government hospitals, where the patient dose report CT dose index, and dose length product were obtained (DLP and CTDIv). As shown in Figure 3.1

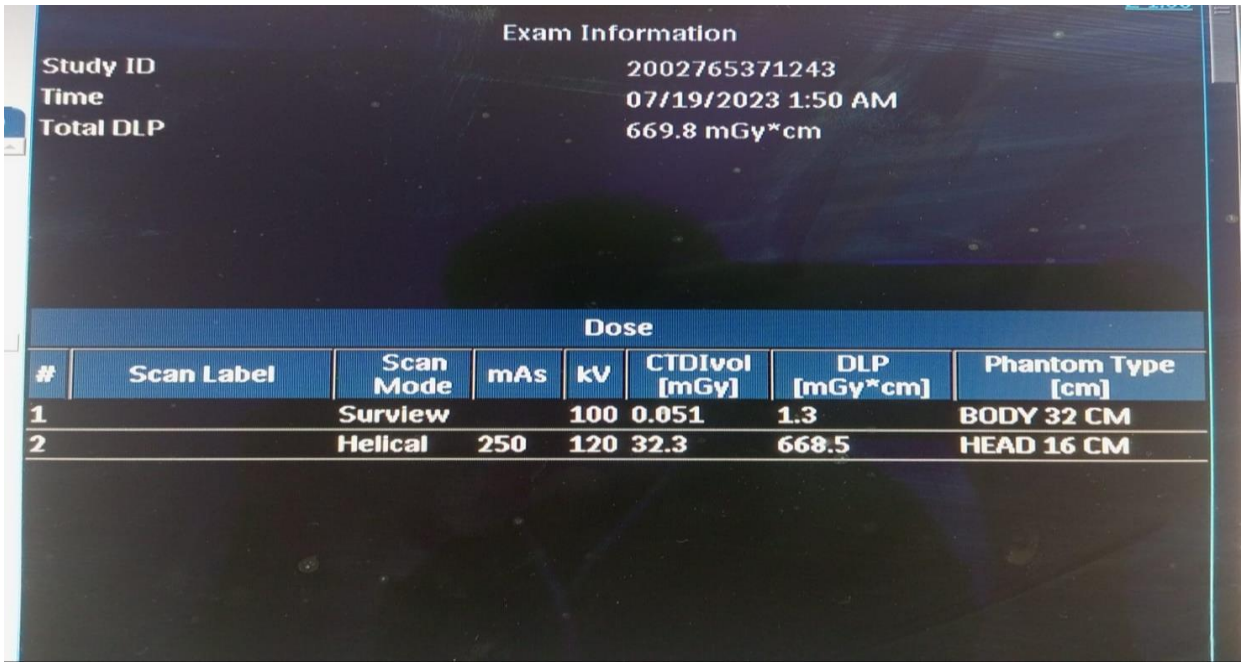


Figure 3.1: Dosage Report for Brain CT scan from the Device Screen.

Stradus (Hospitals, imaging facilities, and radiology clinics can all benefit from Stradus' **PACS** and radiologist systems. Additionally, Stradus gives radiologists access to tools for remotely preparing, viewing, sharing, archiving, and displaying patient image data.) Figure 3.2

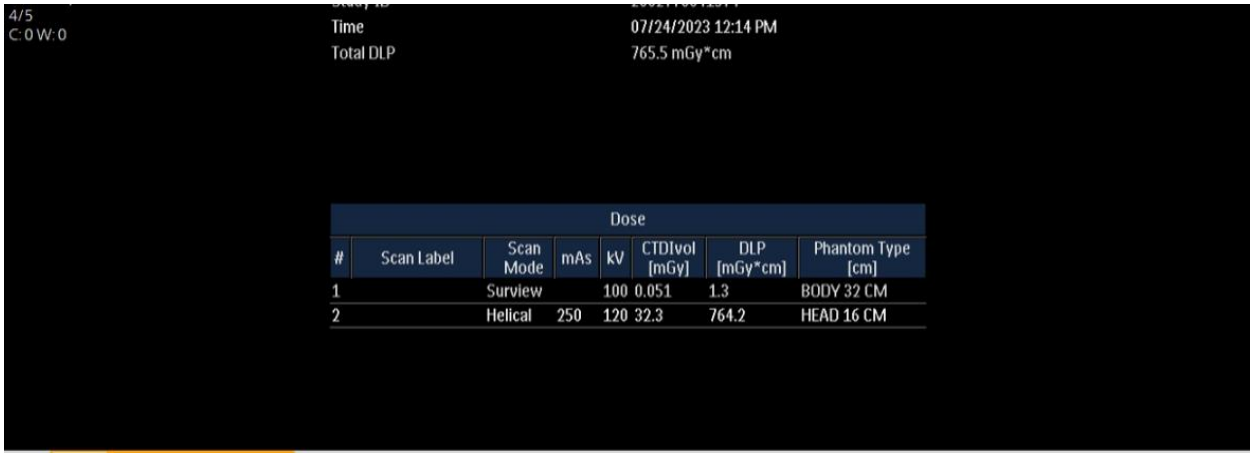


Figure 3.2: Dosage Report for a Brain CT scan From the Stradus Archive Program.

3.3 Imaging Procedures

All CT scans were performed on eleven Philips and GE CT scans these devices included rows of detectors between 16 and 128 detectors. To design the scan range, the patient's head was positioned on the head holder while anterior posterior and lateral scout images were taken. The lower boundary of the posterior fossa and the top of the brain was covered by axial CT scans taken in a line parallel to the orbit meatal line.

Only in some hospitals to adjust radiation exposure for each patient and for each location, tube current was modulated using automatic control modulation.

This software automatically determines the tube current of the X-ray generator depending on X-ray attenuation by the imaging object, as assessed on the scout image. In larger patients, tube current and consequently radiation exposure increases to compensate for stronger attenuation and maintain the image quality constant. In this study, the maximum current was high and the minimum current was low, so there was no effect of these parameters on tube current modulation.

Other imaging parameters were as shown in the table 3.2

Table 3.2 CT Scan Examinations of Pediatrics Brains in Palestinian GHs ((Hospitals, Devices, and Parameters)

Status	devices	kVp	mAs	PITCH + Rotation T	Scan time
AGH	Philips, Incisive CT 128 scanner	80	306	0.4 (Rotation time 0.4)	4.5 s
BGH	Philips, Brilliance 16-slice	120	399	0.69 Rotation time 0.5	11.018 s
JGH	GE 128 Revaluation EVO	100	153	0.969 (Rotation time 0.9) Slice thickness 1.25	13.20 s
RGH	Philips, Ingenuity CT, 128 slice	80/120	300	0.203/0.298/0.390	10.5 s
SGH	Philips, Ingenuity CT, 128 slice	100/120	300-590	**0.297**/0.3 / 0.399	7.7 s
TGH	Philips M x 16 slice	90/120	330-450	0.6713	11.7 s
GGH	Philips, Brilliance 64	120	300	0.673 Rotation t 0.75	6.211 s
RMC1	Philips, Ingenuity 128	80/120	250-300	0.298/**0.390**/0.392	10.5 s
RMC2	Philips, Brilliance 64	120	280	0.673 (Rotation t 0. 5)	4.141 s
RMC3	GE 128 Revaluation EVO	100	176	0.531 Rotation T 0.8 Slice thickness 2.5 mm	11.9 s
YGH	GE 128 Revaluation EVO	120	160	0. 969	13 s

Ramallah Palestine Medical Complex 1 (Emergency department (RMC 1) , Ramallah Palestine Medical Complex 2 (Ramallah sons' section (RMC 2) , Ramallah Palestine Medical Complex 3 *GE CT scan* (Ramallah sons' section (RMC3),Martyr Khalil Suleiman Governmental Hospital-Salfeet (SGH) , Rafidia G Hospital (RGH), Abu Al-Hassn Governmental Hospital – Yatta (YGH) , Al-Hussein Governmental Hospital - Beit Jala G hospital (BGH) , Darwish Nazzal Governmental Hospital (QGH) , Alia Governmental Hospital or Hebron Governmental Hospital (AGH) ،Tubas Turkish Governmental Hospital (TGH), Martyr Yasser Arafat Governmental Hospital (SGH).

3.4 Ethical Considerations

The researcher obtained permission to conduct the necessary examination for the approval of the facility for graduate studies of AAUP was obtained (Appendix A).
The participating patients from the Palestinian Ministry of Health (Appendix B). The approval of the Scientific Research Ethics Committee at the Arab American University (IRB) was obtained (Appendix C).

3.5 Data Collection

The study was performed at nine GHs and conducted on two types of computed tomography devices, which are currently available in the Ministry of Health, Philips, and GE, and have multiple detectors (16-128) slice. Data was collected from some hospitals from patient files stored on CT scanners (report dose) and the stradus (archiving system) program was used to obtain most of the data. All pediatric patients who had CT brain scans without contrast media were counted within three months from 1/12/2022 - 28/2/2023. Children's data was collected for the ages of newborns and up to 18 years, the data included gender, age, computed tomography dose indicators CTDI volume and DLP for calculating the radiation dose during computed tomography to provide individual patient dose estimates. The total number of children who underwent CT scans of the brain reached two hundred and sixty (2160) cases from all Hospitals as shown in Table 3.3.

Table 3.3: The Total Number of Children Who Underwent Brain CT scans in GHs

		GENDER			
		Male		**Female**	
		Count	Table N %	Count	Table N %
	Yatta	84	3.9%	63	2.9%
	Ramallah Medical Complex 1	174	8.1%	86	4.0%
	Ramallah Medical Complex 2	81	3.8%	54	2.5%
	Ramallah Medical Complex 3	24	1.1%	20	0.9%
	Qalqilya Hospital	121	5.6%	60	2.8%
	Tubas Hospital	73	3.4%	43	2.0%
	Salfeet Hospital	70	3.2%	33	1.5%
	Rafidia Hospital	344	15.9%	139	6.4%
	Jenin Hospital	105	4.9%	64	3.0%
	BeitJla Hospital	302	14.0%	171	7.9%
	Alia Hospital	28	1.3%	21	1.0%
	Total	**1406**	**65.1%**	**754**	**34.9%**

In all government hospitals over three months, the total number and gender distribution of patients who underwent brain CT scans were shown in Figure 3.3

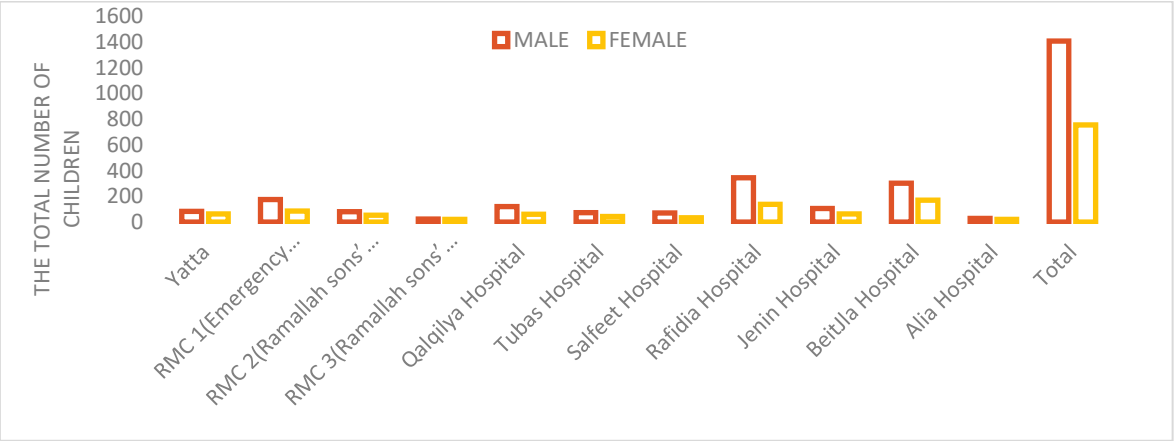


Figure 3.3: The Total Number of Children Who Underwent Brain CT scans in GHs.

3.6 Data Analysis

This study retrospectively analyzed case data for brain CT scans without contrast media in young patients younger than 18 years (1406 males and 754 females). As in Table 3.3 Patients' data were classified and calculated, and the percentage of patients' data was determined by gender for each of the study hospitals through the Excel program, the data were analyzed and the minimum, maximum, and arithmetic mean values were calculated, in addition to the 25 percentile, Percentage 50, Percentage 75, for DLP and CTDI v.

The patients' data obtained in this study were tabulated and classified into age groups **(>1 year, < 1-5 years, < 5-10 years, <10-15 years <15-18 years).**

3.7 Statistical Analysis

Data were collected on the Excel program.

The data were analyzed using the SPSS program and an Excel sheet form, where the mean, percentage 50, percentage 75, Maximum and minimum values ,standard deviation, and R-squared values range of the CT examination dose reports (CTDIv) and (DLP) counting, Comparisons were made between Palestinian government hospitals among themselves and the tables of other countries showing the differences in dosage prescriptions.

To find out if there are any significant differences in the presence of two or more independent variables in this study.

The values were presented as the arithmetic mean and the Percentile 75 of the DLP & $CTDI_V$ values.

The amount of dispersion of the values from their arithmetic mean was calculated. The statistical tests used in this study were the descriptive T-test and ANOVA test.

To find out the probability of coincidence in the observed difference between the groups values the P value at < 0.05.

ANOVA test was in investigate CTDI $_V$ value according number of patients in the age groups and DLP measurement.

These values were expressed as the range of R-squared values also using the diagram.

The interest in this study was to evaluate our measurements for different age groups when imaging children's brains and our measurements will also be discussed in this study with other global measurements of the 75 percentile.

We have previously explained the reason for choosing the 75% rate in this study and other studies.

Chapter Four

Result and Discussion

Introduction

Protecting children from ionizing radiation in medical applications, especially pediatric brain CT scans is very important, therefore, it is necessary to measure the patient's dose to verify that the radiation dose is acceptable, especially when compared with the published DRL. Therefore, the thesis will create a new measurement of DLP and $CTDI_V$ CT of the brain pediatric imaging to compare these data with international values.

4.1. Result

The statistical data from 2160 CT brain scans without contrast media, performed on all patients in GH_S under the age of eighteen, were examined retrospectively in this study gender and age group statistics inside each hospital were studied, followed by the total number of age groups for all hospitals as if they were in one facility.

Additionally, correlation analysis was carried out, which sheds light on the connections between the most crucial components of the study. Standard deviations of DLP and $CTDI_V$ values were determined in GH_S where CT scans were performed. As shown as Table 4.1

The results for each were median values for $CTDI_V$ and DLP as follows the highest values depending on gender were for Yatta Hospital, where the values of each of Median CTDI v = 81.39 mGy for females and 67.82 mGy for males and the Median for DLP = 1479.09 mGy.cm for females and 1519.78 mGy.cm for males. While the percentile was 75% for CTDI v = 81.39 mGy for males and 81.39 mGy for females the percentile

was 75% for DLP = 1641.87 mGy.cm for males and 1601.17 mGy.cm for females. As shown in Figure 4.2 & 4.3.

Table 4.1. Standard deviations of DLP and $CTDI_V$ values for Brain CT scan were performed in GH_S.

Hospital		GENDER	N	Mean	Std. Deviation	t	df	Sig. (2-tailed)
Yatta	DLP	Male	84	1403.7769	383.97880	-.141	145	.888
		Female	63	1412.8316	384.96047	-.141		
RMC 1	DLP	Male	174	774.1621	517.82640	1.172	258	.242
		Female	86	707.8070	119.02700	1.607		
RMC 2	DLP	Male	81	783.8926	125.02579	-.852	133	.396
		Female	54	803.7833	144.07555	-.828		
RMC 3	DLP	Male	24	1299.7837	131.88012	-.765	42	.449
		Female	20	1335.1605	174.84932	-.745		
Qalqilya Hospital	DLP	Male	121	1087.3520	278.33074	-1.207	179	.229
		Female	60	1268.5033	1607.63698	-.866		
Tubas Hospital	DLP	Male	73	1337.5240	227.86417	.111	114	.912
		Female	43	1332.6493	228.10366	.111		
Salfeet Hospital	DLP	Male	70	1195.8000	435.76829	-.260	101	.796
		Female	33	1218.1939	341.45926	-.283		
Rafidia Hospital	DLP	Male	344	925.4381	392.86229	.467	481	.641
		Female	139	896.4345	974.54385	.340		
Jenin Hospital	DLP	Male	105	784.2550	203.25063	2.809	167	.006
		Female	64	695.5233	192.33912	2.847		
BeitJla Hospital	DLP	Male	302	1109.1474	241.64111	1.921	471	.055
		Female	171	1066.4504	214.77448	1.984		
Alia Hospital	DLP	Male	28	497.1679	105.30554	.979	47	.332
		Female	21	466.6186	111.68158	.971		
Total	DLP	Male	1406	1002.7078	395.18782	.066	2158	.948
		Female	754	1001.1694	690.64418			

Hospital		GENDER	N	Mean	Std. Deviation	t	df	Sig. (2-tailed)
Yatta	CTDI vol	Male	84	65.8083	17.61323	-.488	145	.626
		Female	63	67.2648	18.29742	-.485		
RMC 1	CTDI vol	Male	174	34.2004	10.68726	.480	258	.632
		Female	86	33.5476	9.53388	.499		
RMC 2	CTDI vol	Male	81	33.0691	3.95587	-.736	133	.463
		Female	54	33.4943	1.86332	-.838		
RMC 3	CTDI vol	Male	24	63.3142	8.81743	-2.034	42	.048
		Female	20	67.5225	3.01876	-2.189		
Qalqilya Hospital	CTDI vol	Male	121	53.0040	16.28331	.064	179	.949
		Female	60	52.8333	17.99923	.062		
Tubas Hospital	CTDI vol	Male	73	59.7118	22.53778	1.382	114	.170
		Female	43	52.9672	29.62118	1.289		
Salfeet Hospital	CTDI vol	Male	70	51.5886	17.50907	-.593	101	.554
		Female	33	53.6455	13.79588	-.646		
Rafidia Hospital	CTDI vol	Male	344	34.5517	13.46363	.472	481	.637
		Female	139	33.8922	14.96700	.451		
Jenin Hospital	CTDI vol	Male	105	40.6156	10.06981	2.518	167	.013
		Female	64	37.0077	7.00426	2.741		
Beitjala Hospital	CTDI vol	Male	302	48.6026	12.94705	-1.154	471	.249
		Female	171	49.9573	10.95961	-1.208		
Alia Hospital	CTDI vol	Male	28	20.8621	3.24528	-.130	47	.897
		Female	21	21.0000	4.16029	-.126		
Total	CTDI vol	Male	1406	43.7220	17.32864	-.992	2158	.321
		Female	754	44.5133	18.28307	-.976		

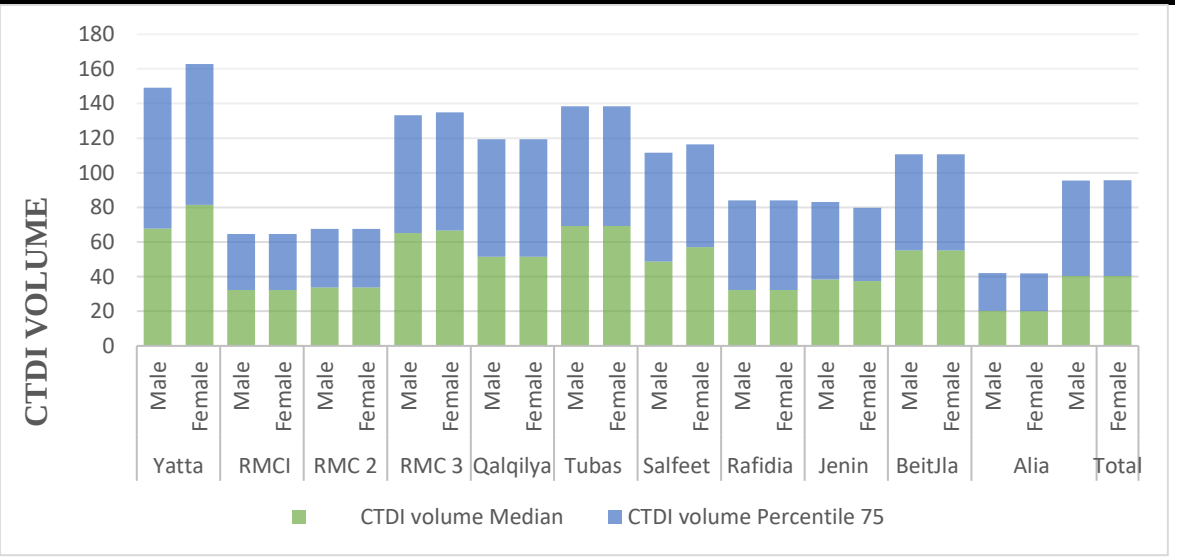


Figure 4.1: The Value of $CTDI_V$ Based on Gender during Pediatrics Brain CT Scan Imaging in GH.

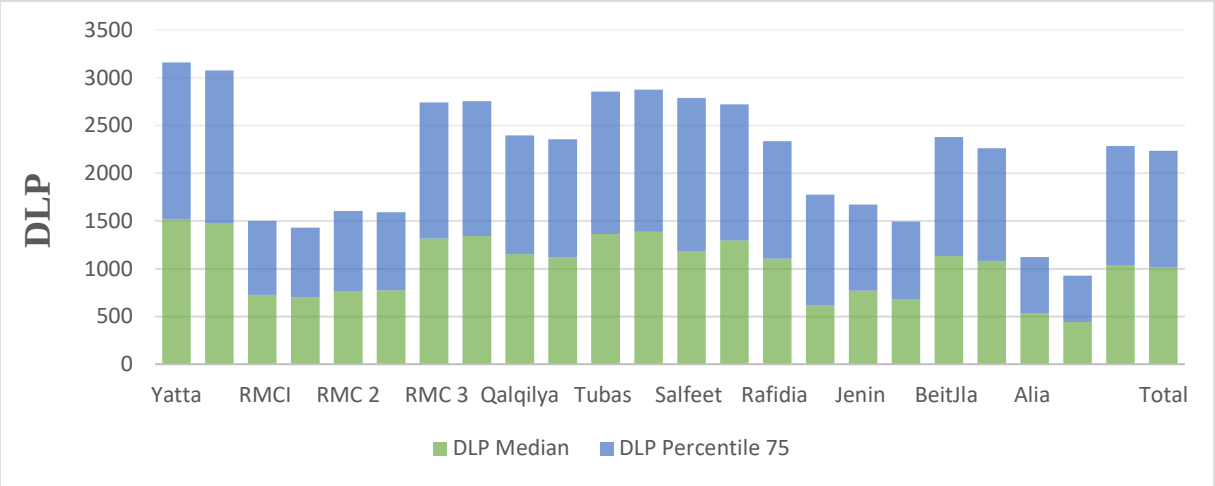


Figure 4.2: The Value of DLP Based on Gender during Pediatrics Brain CT Scan Imaging in G.H.

For DRL values (CTDI V & DLP), the 75% percentile was used in this investigation.

This study relies on the percentile of 75% for DRL values (CTDI $_V$ & DLP). The lowest value was in ***Alia*** GH, where the values of each of Median CTDI v = 20.09 mGy for females and 20.09 mGy for males, and the percentile 75% for CTDI v = 21.74 mGy for females and 21.72 mGy for males.

While the Median DLP in Alia GH = 534.17 mGy.cm for males and 442.43 mGy.cm for females the percentile 75% for DLP = 589.93 mGy.cm for males and 484.55 mGy.cm for females.

However, the total DLP values of all GHs by gender were high compared to the rest of the countries. The total median $CTDI_V$ values of all GHs by gender were 40.38 mGy for males and 40.35 mGy for females, The percentile 75% for $CTDI_V$ = 55.2 for males and 55.4 mGy for females, The total median DLP values of all GHs by gender 1038.78 mGy for males and 1016 mGy for females and The percentile 75% for DLP = 1248.49 for males and 1219.77 mGy for females). As shown in Table 4.2.

Table 4.2: The Value of $CTDI_V$ & DLP Based on Gender for Pediatrics Brain CT scans in GH_S

		CTDIv		DLP	
		Median	**Percentile 75**	**Median**	**Percentile 75**
Yatta	***Male***	***67.82***	***81.39***	***1519.78***	***1641.87***
	Female	***81.39***	***81.39***	***1479.09***	***1601.17***
RMCl	Male	32.3	32.3	725	777.4
	Female	32.3	32.3	699.7	731.8
RMC 2	Male	33.82	33.82	767	838.3
	Female	33.82	33.82	774.65	817.9
RMC 3	Male	65.11	68.15	1317.57	1425.92
	Female	66.72	68.23	1343.12	1414.81
Qalqilya	Male	51.49	67.82	1152.7	1243.5
	Female	51.49	67.82	1120.75	1238.1
Tubas	Male	69.19	69.22	1365.49	1490.1
	Female	69.18	69.22	1386.44	1489.56
Salfeet	Male	48.65	62.9	1186	1603
	Female	57	59.4	1296	1427
Rafidia	Male	32.3	51.7	1106	1230
	Female	32.3	51.7	616.4	1160
Jenin	Male	38.31	44.82	769.57	903.99
	Female	37.53	42.19	684.66	809.02
Beitjala	Male	55.2	55.4	1132.2	1248.5
	Female	55.2	55.4	1082.4	1182
Alia	***Male***	***20.29***	***21.72***	***534.17***	***589.93***
	Female	***20.09***	***21.74***	***442.43***	***484.55***
	Male	40.38	55.2	1038.78	1248.49
Total	Female	40.35	55.4	1016	1219.77

Represent the previous values graphically as shown in the. Figure 4.3

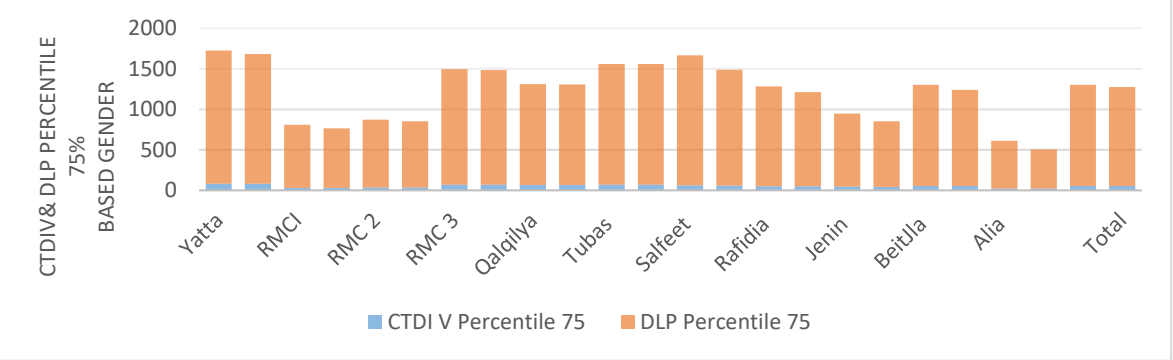


Figure 4.3: The Value of $CTDI_V$ & DLP for the Percentile 75% Based on Gender for Pediatric Brain CT Scans in GH.

For DRL values (CTDI $_V$ & DLP), the 75% percentile was used in this investigation.

This study relies on the percentile of 75% for DRL values (CTDI $_V$ & DLP).

There was a clear difference in CTDI$_V$ and DLP values between government hospitals, according to age groups, and these values vary, as shown in Figure 4.4

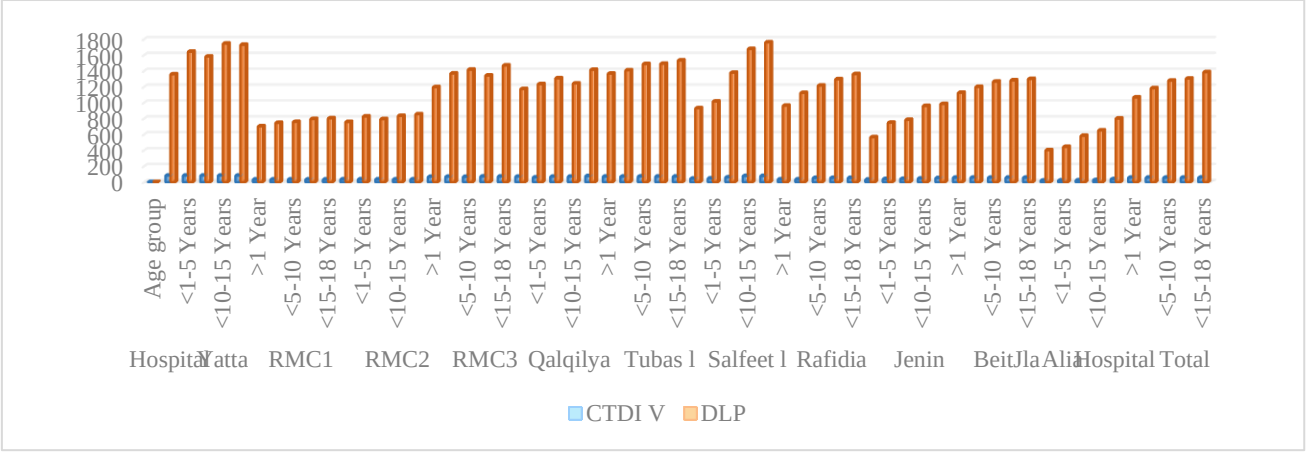


Figure 4.4: The CTDI$_V$ and DLP value in percentile 75% for GH$_S$ based on age groups for Pediatrics Brain CT scans in GH.

The results showed the total number of CTDI$_V$ and DLP values in the 75% percentile for GH$_S$ based on age group during pediatric brain CT. (The percentile 75% CTDI$_V$ = >1 Year = 55.20, <1-5 Years = 55.20, < 5-10 Years= 55.20, < 10-15 Years 55.40, <15-18 Years = 56.14 mGy.(The percentile 75% DLP = >1 Year = 1066, <1-5 Years = 1182, < 5-10 Years= 1276.87, <10-15 Years 1303.05, <15-18 Years = 1383.59 mGy.cm. As shown as in Table 4.3

Table 4.3: The Percentile 75% DRLs (CTDI $_V$ & DLP) for Our Study.

Age Groups									
>1 year		<1-5 years		<5-10 years		<10-15 years		<15-18 years	
Percentile 75		**Percentile 75**		**Percentile 75**		**Percentile 75**		**Percentile 75**	
CTDIv	**DLP**	**CTDIv**	**DLP**	**CTDIv**	**DLP**	**CTDIv**	**DLP**	**CTDIv**	**DLP**
55.20	1066	55.20	1182	55.20	1276.87	55.40	1303.05	56.14	1383.59

In addition, we can see how the CTDI $_{v}$ & (DLP) values relate to each other.

At the 75 percentile for different age groups when imaging the brain. As shown in Figure 4.5

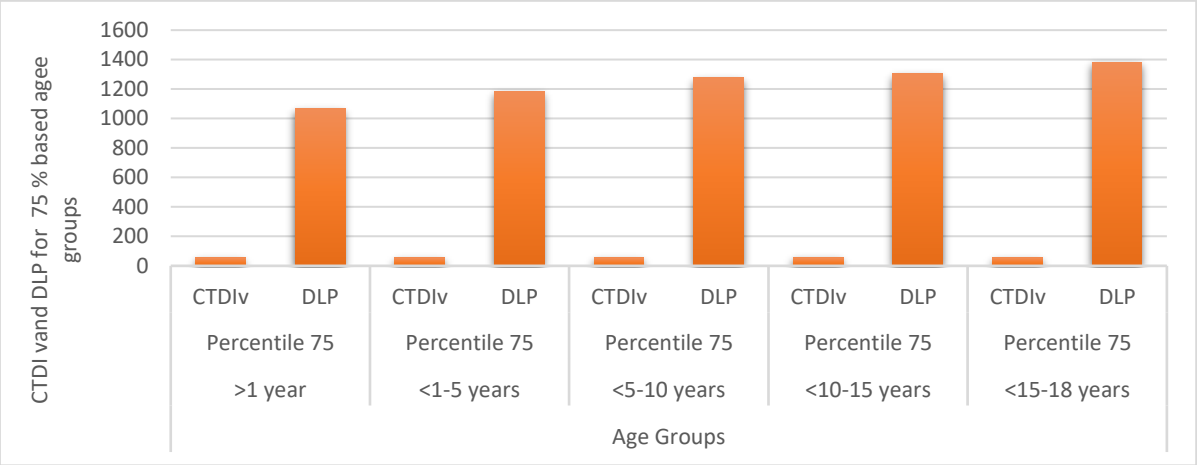


Figure 4.5: The Value of CTDI$_{V}$ & DLP for the percentile 75% based on age groups for Pediatrics Brain CT scans in GHs.

It was also noted in this study that the value of CTDI$_{V}$ & DLP differed from one hospital to another based on the age groups, where the lowest values were in **Alia** G.H, where **the median CTDI v** (>1 Year = 17.36, <1-5 Years = 19.04, <5-10 Years= 21.59, < 10-15 Years 25.26, <15-18 Years = 36.38) mGy and the Percentile 75 (>1 Year = 17.36, 1-5 Years = 19.04, <5-10 Years= 21.59, <10-15 Years 25.26, <15-18 Years = 36.38 mGy).

Median DLP (>1 Year = 379.30, < 1-5 Years = 396.55, < 5-10 Years= 536.83, < 10-15 Years 649.15, <15-18 Years = 800.45) mGy.cm and the Percentile 75 (>1 Year = 401.22, <1-5 Years = 442.43, <5-10 Years= 582.72, < 10-15 Years 649.15, < 15-18 Years = 800.45 mGy.cm.

But in **Yatta** GH the great values of CTDI $_{v}$ & DLP were **median CTDI v** (<1 Year = 52.63, <1-5 Years = 81.39, <5-10 Years= 60.62, <10-15 Years 81.39, <15-18

Years = 81.39) mGy and the Percentile 75 (>1 Year = 81.39, <1-5 Years = 81.39, <5-10 Years= 81.39, <10-15 Years 81.39, <15-18 Years = 81.39 mGy).

Median DLP (>1 Year = 811.74, <1-5 Years = 1555.32, < 5-10 Years= 1499.44, < 10-15 Years 1621.52, < 15-18 Years 1528.70) mGy.cm and the Percentile 75 (>1 Year = 1357.01, <1-5 Years = 1641.87, < 5-10 Years= 1580.60, <10-15 Years 1743.61, <15-18 Years = 1728.73 mGy.cm. as shown in Table 4.4

Table 4.4: The Value of $CTDI_V$ & DLP Based Total Age Groups during Pediatrics Brain CT Scans Imaging in GHs

		CTDI $_V$		DLP	
Hospital	**Age group**	**Median**	**Percentile 75**	**Median**	**Percentile 75**
	>1 Year	52.63	81.39	811.74	1357.01
	<1-5 Years	81.39	81.39	1555.32	1641.87
Yatta	<5-10 Years	60.62	81.39	1499.44	1580.6
	<10-15 Years	81.39	81.39	1621.52	1743.61
	<15-18 Years	81.39	81.39	1528.7	1728.73
RMC1	>1 Year	32.3	32.3	699.6	701.75
	<1-5 Years	32.3	32.3	699.8	745.3
	<5-10 Years	32.3	32.3	712.6	757.6
	<10-15 Years	32.3	32.3	745.2	794
	<15-18 Years	32.3	32.3	732	803.3
	>1 Year	33.82	33.95	756.8	756.8
RMC2	<1-5 Years	33.82	33.92	767	825.55
	<5-10 Years	33.82	33.82	756.8	792.2
	<10-15 Years	33.82	33.82	812.8	833.2
	<15-18 Years	33.82	33.82	815.35	853.6
	>1 Year	65.11	65.11	1195.48	1195.48
RMC3	<1-5 Years	65.76	66.93	1327.36	1366.97
	<5-10 Years	65.11	65.76	1358.05	1415.23
	<10-15 Years	69.83	70.54	1321.16	1341.76
	<15-18 Years	68.75	68.75	1405.03	1468.47
	>1 Year	51.49	67.82	1088.8	1171.65

Qalqilya	<1-5 Years	51.49	58.11	1117.3	1233.5
	<5-10 Years	51.49	67.82	1237.9	1307.05
	<10-15 Years	52.29	67.82	1177.7	1241.1
	<15-18 Years	52.14	74.6	1247.7	1413.6
	>1 Year	58.45	69.21	1052.41	1365.14
Tubas l	<1-5 Years	58.45	69.22	1241.07	1407.18
	<5-10 Years	69.19	69.57	1386.43	1485.84
	<10-15 Years	52.63	69.19	1386.44	1489.56
	<15-18 Years	69.21	69.22	1407.08	1531.61
	>1 Year	42.6	42.6	888.9	929.7
Salfeet l	<1-5 Years	41.7	46.5	908.2	1015
	<5-10 Years	59.4	59.4	1291.5	1377
	<10-15 Years	59.4	76.2	1581	1676
	<15-18 Years	76.2	76.2	1691.5	1759.5
	>1 Year	23.6	33.82	419.25	961.3
Rafidia	<1-5 Years	32.3	33.95	562.75	1122.5
	<5-10 Years	32.3	51.7	1096	1215
	<10-15 Years	33.82	51.7	1215	1295
	<15-18 Years	51.7	51.7	1257	1360
	>1 Year	29.16	30.74	481.55	564.2
Jenin	<1-5 Years	33.34	37.85	616.36	747.42
	<5-10 Years	37.11	39.42	679	783.49
	<10-15 Years	41.37	44.55	820.92	958.29
	<15-18 Years	47.04	49.67	903.99	983.37
	>1 Year	48.35	55.4	1016	1123.9
Beitjala	<1-5 Years	55.2	55.4	1099	1198.7
	<5-10 Years	55.2	55.4	1148.8	1265.1
	<10-15 Years	55.4	55.4	1182	1281.7
	<15-18 Years	55.2	55.4	1182	1298.3
	>1 Year	17.36	18.32	379.3	401.22
Alia	<1-5 Years	19.04	20.09	396.55	442.43
Hospital	<5-10 Years	21.59	21.74	536.83	582.72
	<10-15 Years	25.26	25.26	649.15	649.15
	<15-18 Years	36.38	36.38	800.45	800.45
	>1 Year	**33.82**	**55.2**	**769.9**	**1066**
	<1-5 Years	**34.6**	**55.2**	**908.2**	**1182**
Total	<5-10 Years	**40.72**	**55.2**	**1099**	**1276.87**
	<10-15 Years	**43.99**	**55.4**	**1132.2**	**1303.05**
	<15-18 Years	**51.49**	**56.14**	**1187**	**1383.59**

The results of this study were the sum of the median values $CTDI_V$ & DLP together of the brain scans in all GHs (As if it were in one facility) Table 4.5.

Table 4.5 :The Sum of the Mean Values $CTDI_V$ and DLP for GH_S

>1 year		**<1-5 years**		**<5-10 years**		**<10-15 years**		**<15-18 years**	
Median		Median		Median		Median		Median	
CTDIv	DLP	CTDIv	DLP	CTDIv	DLP	CTDIv	DLP	CTDIv	DLP
33.82	769.90	34.60	908.20	40.72	1099	43.99	1132.20	51.49	1187

We note the relationship for the mean values of each $CTDI_V$ & DLP by age group as shown in Figure 4.6

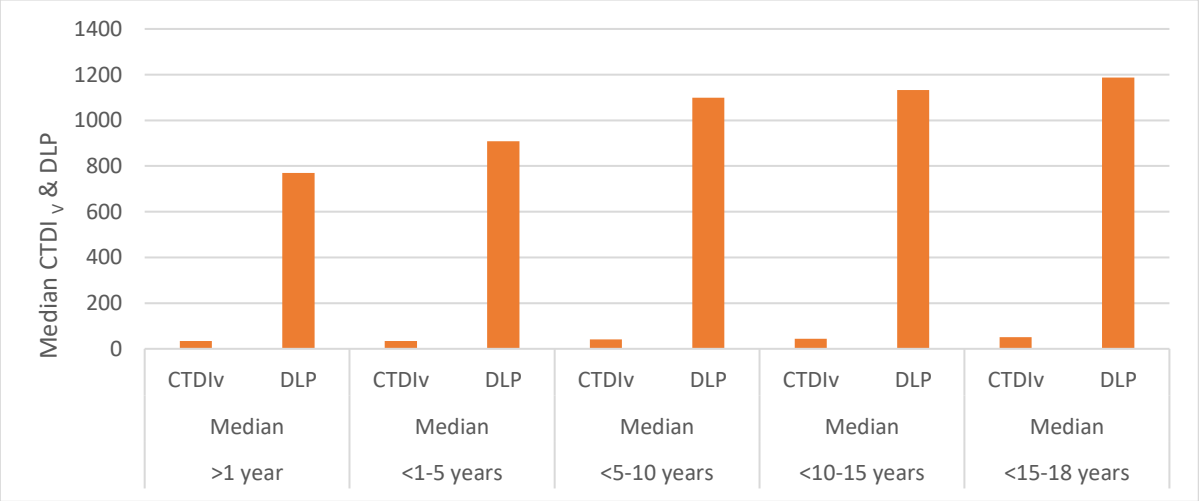


Figure 4.6: Median CTDI $_V$ & DLP) of the Brain Scans for the Age Groups for GH_S.

4.1.1 The Correlation Analysis

The values of CTDI $_V$ P > 0.321 and P > 0.948 for DLP were determined through statistical analysis and calculation of the correlation coefficient value for DRL_S ($CTDI_V$&DLP). They were values P > 0.05 based on gender.

Therefore, the values are not (statistically significant) hence the assumption that there is a relationship between values ($CTDI_V$ and DLP) according to gender, this hypothesis is rejected. As shown in Figure 4.7.

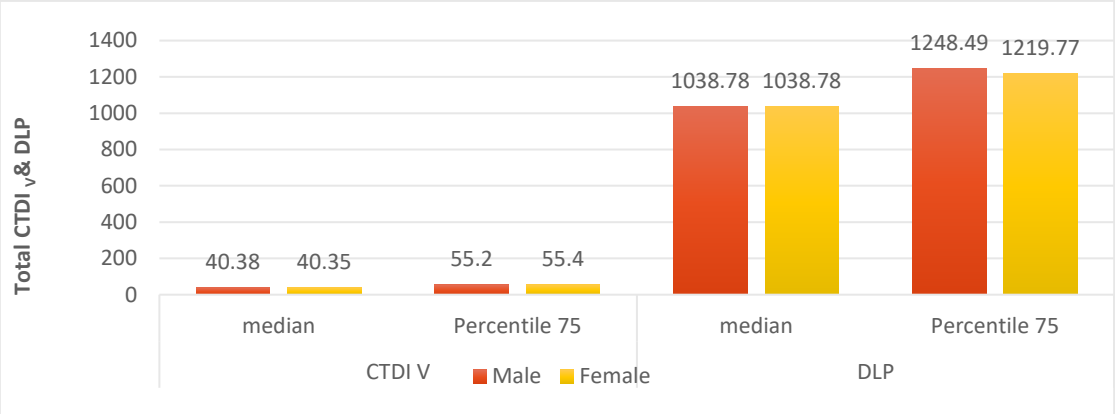


Figure 4.7: Total for (median and percentile 75 %) DRLS (CTDI $_V$ & DLP) by Gender in GHs

However, it was discovered that there were statistically significant variations in the value, ($p \leq 0.05$), where P-value = 0.00, for values (CTDI $_V$ & DLP) based on age group for each hospital. This shows a significant disparity in the DLP values observed during pediatric brain imaging, which represent the actual dose received by the patient. Each hospital's age groups DLP and CTDI$_V$ values are shown with their standard deviations from the mean. As shown as Table 4.6.

Furthermore, the standard deviation of DLP values from the arithmetic mean in GHs was calculated for each age groups. As shown as Table 4.7.

Table 4.6: The Age Groups Standard Deviation of CTDI$_V$ values at GHs from their Arithmetic Means.

Hospital / CTDI vol		N	Mean	Std. Deviation
Yatta	>1 Year	26	58.3931	17.77484
	<1-5 Years	59	68.4034	16.43066
	<5-10 Years	28	60.1979	20.60121
	<10-15 Years	16	74.1600	14.71847
	<15-18 Years	18	74.4144	13.75618
	Total	147	66.4325	17.86219
RMC 1	>1 Year	40	36.7567	15.35735
	<1-5 Years	87	34.0860	10.77855
	<5-10 Years	49	31.8806	2.82988
	<10-15 Years	35	31.8686	2.16995
	<15-18 Years	49	35.1563	12.09961
	Total	260	33.9845	10.30617

RMC 2	>1 Year	25	30.8540	6.39272
	<1-5 Years	36	33.3897	2.06528
	<5-10 Years	21	34.2990	2.50666
	<10-15 Years	25	33.8512	.05667
	<15-18 Years	28	33.8339	.04095
	Total	135	33.2392	3.28018
RMC 3	>1 Year	5	65.1260	.03578
	<1-5 Years	10	63.8580	7.94612
	<5-10 Years	14	62.3364	9.25951
	<10-15 Years	8	69.1350	3.93789
	<15-18 Years	7	68.5700	2.11858
	Total	44	65.2270	7.07851
Qalqilya Hospital	>1 Year	32	51.6900	18.79380
	<1-5 Years	61	50.6334	16.55406
	<5-10 Years	48	52.3006	16.71640
	<10-15 Years	28	57.6279	15.54112
	<15-18 Years	12	59.7292	14.53536
	Total	181	52.9474	16.82146
Tubas Hospital	>1 Year	7	50.9114	26.50589
	<1-5 Years	33	56.9691	24.61297
	<5-10 Years	28	56.3821	28.59309
	<10-15 Years	13	48.5400	29.54601
	<15-18 Years	35	62.5849	21.83964
	Total	116	57.2116	25.47887
Salfeet Hospital	>1 Year	13	36.1308	10.62022
	<1-5 Years	25	39.6160	8.80898
	<5-10 Years	32	51.9219	11.48892
	<10-15 Years	13	62.9462	13.58127
	<15-18 Years	20	72.0800	7.58757
	Total	103	52.2476	16.37145
Rafidia Hospital	>1 Year	54	25.2493	15.86232
	<1-5 Years	176	31.5908	12.29660
	<5-10 Years	137	35.7371	13.94804
	<10-15 Years	63	40.2310	12.85939
	<15-18 Years	53	42.3177	9.81058
	Total	483	34.3619	13.90036
Jenin Hospital	>1 Year	17	29.3924	2.23637
	<1-5 Years	47	34.5745	5.13432
	<5-10 Years	41	38.1861	5.08977
	<10-15 Years	27	42.2937	6.68784
	<15-18 Years	37	48.6730	11.05674
	Total	169	39.2493	9.17881
BeitJla Hospital	>1 Year	104	45.0784	14.89003
	<1-5 Years	147	50.6949	11.51249
	<5-10 Years	115	49.7912	10.63532
	<10-15 Years	51	51.9835	10.45630
	<15-18 Years	56	48.2718	12.02539
	Total	473	49.0923	12.27122
Alia Hospital	>1 Year	7	17.3429	1.40016
	<1-5 Years	22	19.8868	2.31247
	<5-10 Years	14	21.8136	2.21081

	<10-15 Years	5	24.8920	.50470
	<15-18 Years	1	36.3800	.
	Total	49	20.9212	3.62500
Total	>1 Year	330	40.1161	18.33980
	<1-5 Years	703	42.4972	17.72946
	<5-10 Years	527	43.8032	16.61113
	<10-15 Years	284	46.5363	16.94963
	<15-18 Years	316	49.4355	17.67406
	Total	2160	43.9982	17.66747

Table 4.7: The Age Groups Standard Deviation of DLP Values at GH_S from their Arithmetic Means.

Hospital / DLP		N	Mean	Std. Deviation
Yatta	>1 Year	26	977.4327	364.76939
	<1-5 Years	59	1486.3025	333.39035
	<5-10 Years	28	1399.2836	301.34909
	<10-15 Years	16	1628.0450	233.86067
	<15-18 Years	18	1588.4383	328.85429
	Total	147	1407.6575	383.10654
RMC 1	>1 Year	40	673.4825	65.58122
	<1-5 Years	87	711.9805	125.71675
	<5-10 Years	49	872.4408	962.16142
	<10-15 Years	35	775.4400	131.79555
	<15-18 Years	49	751.1020	60.69972
	Total	260	752.2138	429.80908
RMC 2	>1 Year	25	681.7720	148.26553
	<1-5 Years	36	798.7333	97.33305
	<5-10 Years	21	799.7143	110.23289
	<10-15 Years	25	828.0200	127.56413
	<15-18 Years	28	843.0857	130.33012
	Total	135	791.8489	132.80825
RMC 3	>1 Year	5	1168.0720	80.24197
	<1-5 Years	10	1348.8690	216.45182
	<5-10 Years	14	1323.2679	132.37691
	<10-15 Years	8	1275.4350	123.34398
	<15-18 Years	7	1405.6771	61.12229
	Total	44	1315.8641	152.08250
Qalqilya Hospital	>1 Year	32	960.0531	282.87186
	<1-5 Years	61	1065.1000	245.00751
	<5-10 Years	48	1326.5602	1804.44913
	<10-15 Years	28	1176.3786	127.89361
	<15-18 Years	12	1281.1250	143.01182
	Total	181	1147.4022	951.89204
Tubas Hospital	>1 Year	7	1093.1057	292.62116
	<1-5 Years	33	1248.2730	209.70927
	<5-10 Years	28	1382.3957	183.68384

	<10-15 Years	13	1378.9500	277.40910
	<15-18 Years	35	1413.2854	188.53875
	Total	116	1335.7170	226.97149
Salfeet Hospital	>1 Year	13	782.5308	246.90292
	<1-5 Years	25	892.5040	230.49591
	<5-10 Years	32	1224.0656	309.53773
	<10-15 Years	13	1503.9077	362.85664
	<15-18 Years	20	1635.0000	185.79105
	Total	103	1202.9748	406.38235
Rafidia Hospital	>1 Year	54	574.4944	365.78995
	<1-5 Years	176	777.5750	351.81165
	<5-10 Years	137	924.4029	362.21489
	<10-15 Years	63	1117.3206	333.17861
	<15-18 Years	53	1472.5434	1400.27169
	Total	483	917.0913	617.99719
Jenin Hospital	>1 Year	17	516.0912	105.99068
	<1-5 Years	47	671.7202	199.66286
	<5-10 Years	41	727.6468	164.93929
	<10-15 Years	27	864.0448	165.56911
	<15-18 Years	37	901.4362	138.17473
	Total	169	750.6525	203.24800
Beitjla Hospital	>1 Year	104	988.5661	232.36616
	<1-5 Years	147	1060.4782	226.46891
	<5-10 Years	115	1136.2255	233.32242
	<10-15 Years	51	1164.3206	201.97165
	<15-18 Years	56	1224.6088	169.88734
	Total	473	1093.7115	232.96328
Alia Hospital	>1 Year	7	375.9571	39.39700
	<1-5 Years	22	433.3941	78.54472
	<5-10 Years	14	546.4686	47.07136
	<10-15 Years	5	620.4620	40.17674
	<15-18 Years	1	800.4500	.
	Total	49	484.0753	108.01857
Total	>1 Year	330	815.2193	319.20544
	<1-5 Years	703	930.5874	358.78738
	<5-10 Years	527	1050.4641	696.70925
	<10-15 Years	284	1094.0561	330.47095
	<15-18 Years	316	1193.5348	662.23271
	Total	2160	1002.1707	517.68082

In addition to the presence of statistically significant differences in the values (CTDI $_V$ & DLP) based on age group for the total hospitals on the basis that these values are from one medical facility. Linear regression (R^2) can be used to show this result. (R^2) = 0.9601 (y=37.811x+1053.2) .As shown in figures 4.8, 4.9.

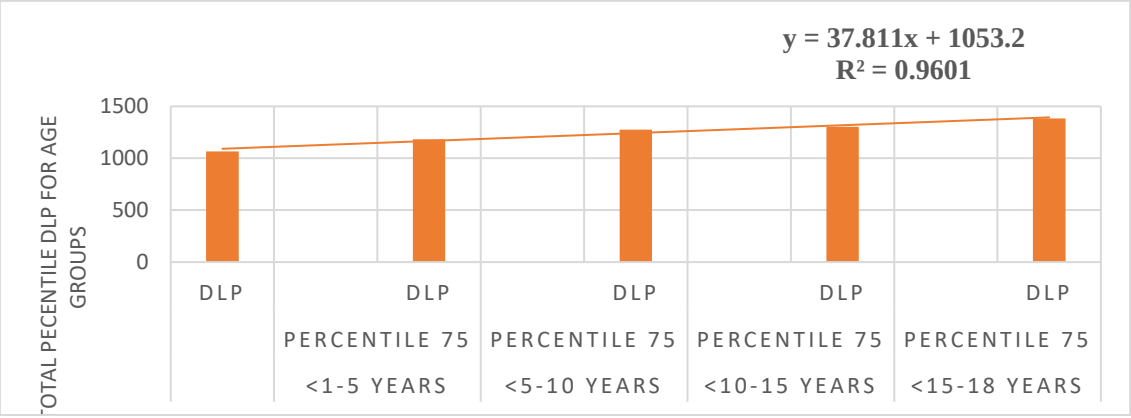


Figure 4.8 : Linear Regression Coefficient R^2 between the DLP Variable and the Total Number of age groups Patients in $G.H_S$.

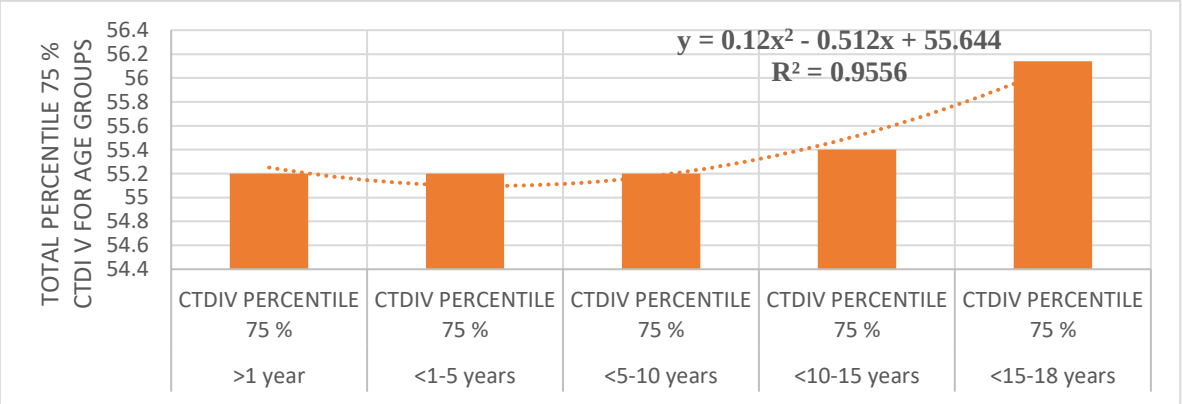


Figure 4.9: The Exponential Coefficient R^2 between the CTDI $_V$ Variable and Age Groups Patients in GH_S.

4.2 Discussion

In this study, we rely on the percentile 75% for DRL values (CTDI $_V$ & DLP) Table 4.4. The **lowest** DLP values were in **Alia** GH based on gender, (The percentile 75% = 589.93 mGy for males and 484.55 mGy for females) while the highest DLP values were in **Yatta** GH, (the percentile 75% = 1603 mGy for males and 1427 mGy for females) However the **total** DLP values of all GHs by gender were high compared to the rest of

the countries. (The percentile 75% = 1248.49 mGy for males and 1219.77 mGy for females).

There is no significant difference in DLP all in GH_S value for gender difference (p-value).

When discussing the median values of CTDI $_V$& DLP between Yatta GH and Alia GH was noticed in Table 4.8.

Table 4.8: The Value of the Median ($CTDI_V$ & DLP) Based on Total Age Groups during Pediatrics Brain CT Scans Imaging in our study and UK.

Yatta Hospital									
>1 year		<1-5 years		<5-10 years		<10-15 years		<15-18 years	
Median		Median		Median		Median		Median	
CTDIv	DLP	CTDIv	DLP	CTDIv	DLP	CTDIv	DLP	CTDIv	DLP
52.63	811.74	81.39	1555.32	60.62	1499.44	81.39	1621.52	81.39	1528.70
Alia Hospital									
>1 year		<1-5 years		<5-10 years		<10-15 years		<15-18 years	
Median		Median		Median		Median		Median	
CTDIv	DLP	CTDIv	DLP	CTDIv	DLP	CTDIv	DLP	CTDIv	DLP
17.36	379.30	19.04	396.55	21.59	536.83	25.26	649.15	36.38	800.45
Total values across all hospitals (Our study)									
>1 year		<1-5 years		<5-10 years		<10-15 years		<15-18 years	
Median		Median		Median		Median		Median	
CTDIv	DLP	CTDIv	DLP	CTDIv	DLP	CTDIv	DLP	CTDIv	DLP
33.82	769.90	34.60	908.20	40.72	1099	43.99	1132.20	51.49	1187
United Kingdom 2022. (Worrall et al., 2022).									
>1 year		<1-5 years		<5-10 years		<10-15 years		<15-18 years	
Median		Median		Median		Median		Median	
CTDIv	DLP	CTDIv	DLP	CTDIv	DLP	CTDIv	DLP	CTDIv	DLP
17.1	248	28.3	372	33.9	626	46.6	882	46.5	983

The variation in $CTDI_V$ levels between Yatta Hospital and Alia GH, which affects DLP values, explains this mismatch in terms of $CTDI_V$ values.

The DLP's median value is higher than the UK's median value for the total values of hospitals in our analysis, but they are located in Alia GH lower than UK values.

The lower median $CTDI_V$ allows for an explanation of this result. Table 4.8

It was also noted in this study that the value of DLP differed from one hospital to another based on the age groups, where the lowest values were in **Alia** G.H, where **The Percentile 75% of the DLP** (>1 Year = 401.22, <1-5 Years = 442.43, <5-10 Years= 582.72, <10-15 Years 649. <15, 15-18 Years = 800.45 mGy.

However, in **Yatta** GH the great values of DLP were the Percentile 75 (>1 Year = 1357.01, < 1-5 Years = 1641.87, <5-10 Years= 1580.60, < 10-15 Years 1743.61, <15-18 Years = 1728.73 mGy. This is due to the imaging protocol of the CT scan devices in **Alia** Hospital using low (kVp) (80), a Rotation time of 0.4, and a Scan time of 4.5 s, it was noted that they use pediatrics protocols.

Decrease the values of $CTDI_V$ in Alia G.H compared to other Hospitals; this explains the low values DLP Dose Index.

The highest value was in **Yatta** GH., it reached 81.39 mGy, and the scan time was 13 s. adult protocols were used during pediatric brain CT scans, and therefore the $CTDI_V$ values in the adult protocol were higher than in the pediatric protocols, which led to an increase in parameters and a noticeable increase in DLP (Walter Huda, 2011).

(The percentile 75% $CTDI_V$ for **Yatta** hospital = >1 Year = 81.39, <1-5 Years = 81.39, <5-10 Years= 81.39, < 10-15 Years 81.93, <15-18 Years = 81.93 mGy.

(The percentile 75% $CTDI_V$ for **Alia** hospital = >1 Year = 18.32, <1-5 Years = 20.09, <5-10 Years= 21.74, <10-15 Years 25.26, <15-18 Years = 36.38 mGy. Table 4.4.

The measurement data show that the Total values of all GHs by age groups are based on percentile 75%, in addition to the median of those values clarified by Table 4.4.

When comparing the results of our study (percentile 75% CTDI $_V$) with international values, we find a noticeable increase in the radiation dose index. As shown in Table 4.9. Which leads to a definite increase in DLP. As shown in Figure 4.10.

Table 4.9: The Percentile of 75% CTDIv for Our Study Compared with Other Countries

Country	Citation	Age Groups				
		>1 year	**<1-5 years**	**<5-10 years**	**<10-15 years**	**<15-18 years**
		CTDI $_V$	CTDI v	CTDI v	CTDI v	CTDI v
		Percentile 75	**Percentile 75**	**Percentile 75**	**Percentile 75**	**Percentile 75**
Our study		55.20	55.20	55.20	55.40	56.14
Germany 2006	(Galanski, Nagel, and Stamm, 2006)	33	40	50	60	
Switzerland 2008	(Verdun et al., 2008).	20	30	40	60	
South Korea 2015	(Hwang *et al.*, 2015).	39.1	41.7	44.1	55.3	
Iran 2019	(Mohammadbeigi *et al.*, 2019).	18.3	18.3	18.3	21.1	
Jordan 2019	(Rawashdeh *et al.*, 2019).	49	55	65	61	
Japan 2020	(Kanda et al., 2021)	30	40	55	60	
Malaysia 2020	(Muhammad *et al.*, 2020)	24	34	32	58	
U.K 2022	(Worrall *et al.*, 2022).	19.7	28.4	35.5	46.8	56.14
Abu Dhabi 2023	(Abulail et al., 2023)	18.4	30	34	45	
Saudi Arabia 2023	(Alhailiy et al., 2023)	25	30	34	45	

We note the discrepancy in global measurements of CTDI$_V$ when imaging the pediatric brain CT scan, as it increases linearly with increasing age groups in measurements for some international countries. Noting that the highest values were in the study conducted in Jordan in 2019, and the lowest values were in the Iran study.

(The percentile 75% CTDI$_V$ for **Jordan 2019** = >1 Year = 49, < 1-5 Years = 55, <5-10 Years = 65, < 10-15 Years 61, 15-18 Years = 61 mGy. In addition, the percentile 75% DLP = >1 Year = 744, <1-5 Years = 982, < 5-10 Years= 1130, <10-15 Years 1207 mGy.cm. The percentile 75% CTDI$_V$ for **Iran 2019** = >1 Year = 18.3, < 1-5 Years = 18.3,

< 5-10 Years = 18.3, 10-15 Years 21.10. Moreover, the percentile 75% DLP = >1 Year = 308.3, <1-5 Years = 326.6, <5-10 Years= 335.6, <10-15 Years 335.7 mGy.cm). Followed by the United Kingdom study in 2022. The values of our previous study are higher than all global value studies.

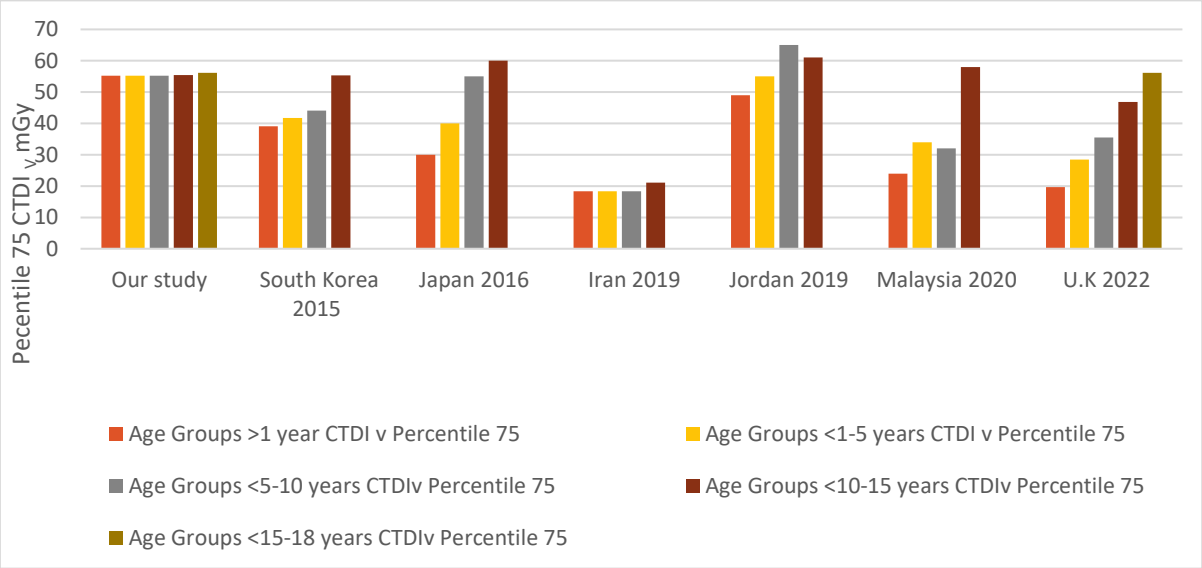


Figure 4.10: Percentile 75% $CTDI_V$ for Paediatric brain CT in our study GH_S with other international.

Studying the global DLP values revealed that they were impacted by rising $CTDI_V$ levels, which helps to explain why measurements in the Jordan study had lower DLP values than those in the Iran study, which had higher DLP values. As shown in Table 4.10.

Table 4.10: The Percentile of 75% DLP for Our Study Compared with Other Countries

Country	Age Groups				
	>1 year	<1-5 years	<5-10 years	<10-15 years	<15-18 years
	DLP	DLP	DLP	DLP	DLP
	Percentile 75	Percentile 75	Percentile 75	Percentile 75	Percentile 75
Our study	***1066***	***1182***	***1276.87***	***1303.05***	***1383.59***
South Korea 2015	545	508	792	947	
Japan 2020	480	660	850	1000	
Iran 2019	***308.3***	***326.6***	***335.6***	***335.7***	
Jordan 2019	744	982	1130	1207	
Malaysia 2020	427	622	646	1041	
U.K 2022	295	538	678	944	
Abu Dhabi 2023	304	385	441	568	
Saudi Arabia 2023	404	560	548	742	

The percentile 75% DLP = >1 Year = 1066, <1-5 Years = 1182, <5-10 Years= 1276.87, <10-15 Years 1303.05, <15-18 Years = 1383.59 mGy. Comparing these values (75% DLP) with international values. As shown in figure 4.11

They were significantly high for all age groups, which increases the risk of cancer in children during brain CT examination (Miglioretti *et al.*, 2013).

The values measurement of the DLP in our study shows that are higher than those other studies in international values.

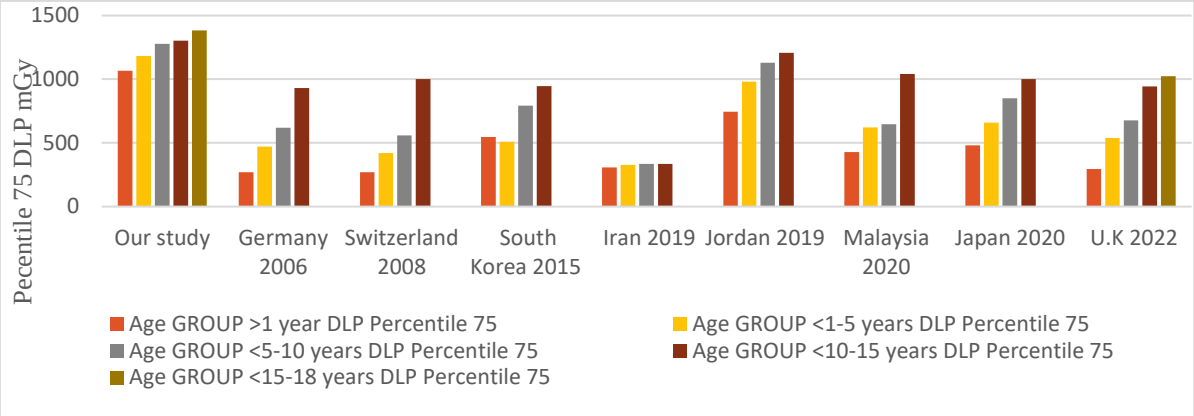


Figure 4.11: Percentile 75 % DLP for Pediatric brain CT in our Study (GH_S) with Other International.

When analyzing statistics and calculating the p-value for DRL_S ($CTDI_V$ & DLP) in most of the data obtained depending on the gender, the probability of a coincidence was great where it was $P > 0.05$. This means that the hypothesis of the existence of a relationship between male and female (gender) in DLP difference in the number of cases in which a CT scan of the brain was performed is a rejected theory. As Table as 4.1, 4.2 With the total values of the $CTDI_V$ data based on gender, they were P-value > 0.321 and P-value > 0. 948 for DLP. (Not considered statistically significant) Shown in Figure 4.12.

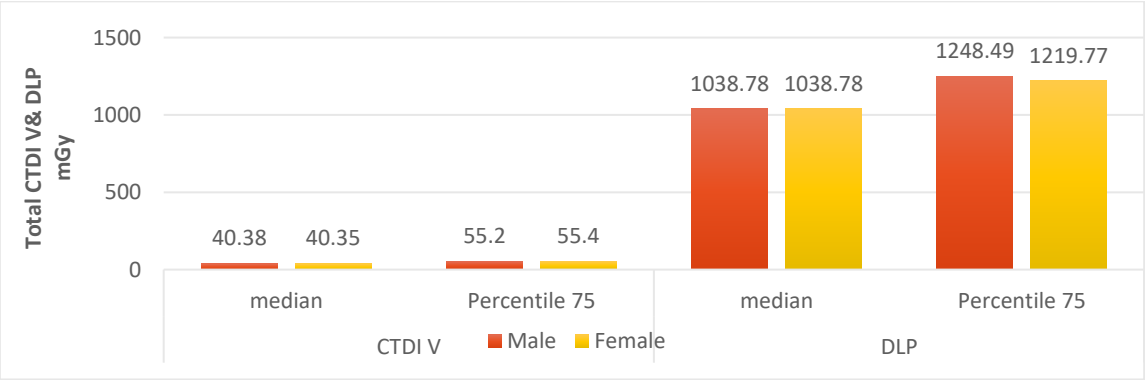


Figure 4.12: Total for (median and percentile 75 %) DRL_S ($CTDI_V$ & DLP) by Gender in GH_S

However, when comparing the DRL_S ($CTDI_V$ & DLP) of each of the age groups hospitalized in this study, it was found that there were statistically significant differences in the probability value, ($p \leq 0.05$), where P-value = 0.00. As Table as 4.6, 4.7

This indicates the large discrepancy in the measured measurement of the DLP values, which indicate the amount of this actual dose absorbed by the patient when imaging the pediatric brain and this result can be explained as linear regression the linear regression coefficient was calculated and analyzed between the DLP variable for a total number of measurement in GH_S. By calculating this value with the known statistical measure, R-squared (R^2) there is a variance between the two variables. Which was equal to **R^2 = 0.9601**, which constitutes an increasing linear regression. Meaning that the model predicts ninety percent of the relationship between age groups and the DLP values (The higher the age groups, the higher the DLP values). As shown in figure 4.13.

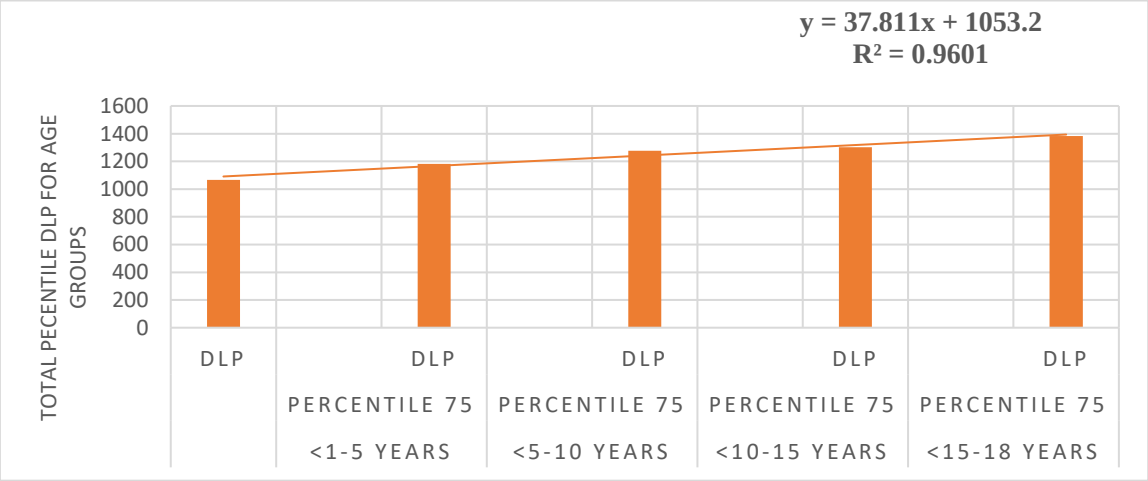


Figure 4.13 : Linear Regression Coefficient R^2 between the DLP Variable and the Total Number of age groups Patients in GH_S.

For $CTDI_V$ there is also a statistically significant relationship for the value of R^2 it was valued **R^2 = 0.9556** in the form of a regression, this means that the relationship between the two variables explains ninety percent of the variance in the data, The regression values variation of the $CTDI_V$ can be interpreted depending on the age groups (CTD_V values rise at the 75 percentile with increasing age groups of patients during a CT scan of the brain. As shown in Figure 4.14**.**

The relationship between the two variables explains 90% of the variance in the data.

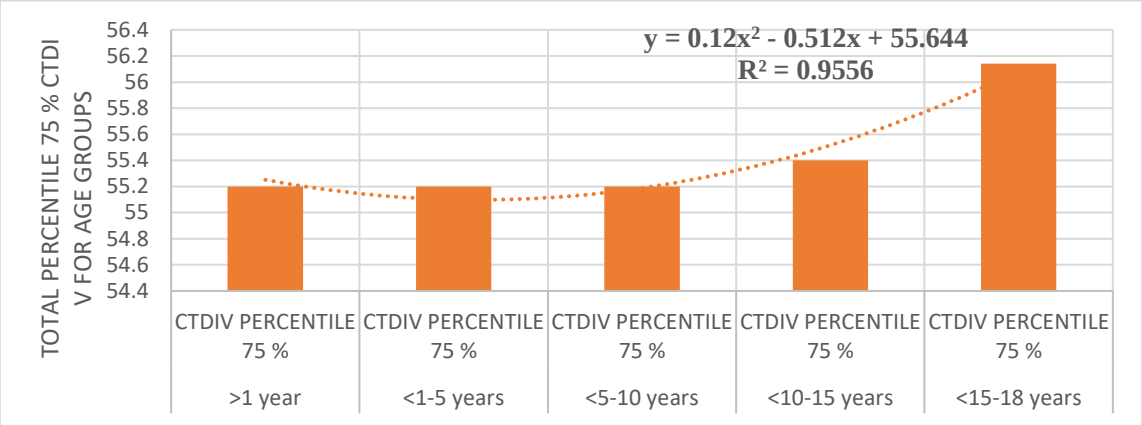


Figure 4.14: The Exponential Coefficient R^2 between the CTDI $_V$ Variable and Age Groups Patients in GHs.

There is an unequal variation in the Percentile 75% of $CTDI_V$ and DLP values between the Ramallah Medical Complex (Ramallah Sons Department) , Jenin and Yatta Hospital, even though all three facilities have the same type and specifications of CT scanner.

As shown as Table 4.11

Table 4.11 CTDI $_V$ and DLP values for Palestine Medical Complex, Jenin, and Yatta Hospital

		CTDI v		DLP	
Hospital	**Age groups**	**Median**	**Percentile 75**	**Median**	**Percentile 75**
	>1 Year	***52.63***	***81.39***	***811.74***	***1357.01***
	<1-5 Years	***81.39***	***81.39***	***1555.32***	***1641.87***
Yatta	***<5-10 Years***	***60.62***	***81.39***	***1499.44***	***1580.6***
	<10-15 Years	***81.39***	***81.39***	***1621.52***	***1743.61***
	<15-18 Years	***81.39***	***81.39***	***1528.7***	***1728.73***
	>1 Year	65.11	65.11	1195.48	1195.48
RMC3	<1-5 Years	65.76	66.93	1327.36	1366.97
	<5-10 Years	65.11	65.76	1358.05	1415.23
	<10-15 Years	69.83	70.54	1321.16	1341.76

	<15-18 Years	68.75	68.75	1405.03	1468.47
	>1 Year	29.16	30.74	481.55	564.2
Jenin	<1-5 Years	33.34	37.85	616.36	747.42
	<5-10 Years	37.11	39.42	679	783.49
	<10-15 Years	41.37	44.55	820.92	958.29
	<15-18 Years	47.04	49.67	903.99	983.37

High DLP values are the result of uneven variance in the 75% percentile of $CTDI_V$ values (RMC3, Yatta, Jenin).These figures exceed the values mentioned in the AAPM study.

Because of ASiR, the logarithm of order Adaptive statistical iterative reconstruction, we simultaneously see a considerable decline in the values of Jenin Hospital.

The values also differed in the Palestine Medical Complex for $CTDI_V$ and DLP.

As shown as Table 4.12.

Table 4.12 $CTDI_V$ and DLP values for Palestine Medical Complex

		$CTDI_V$		**DLP**	
Hospital	Age group	Median	Percentile 75	Median	Percentile 75
RMC1	>1 Year	32.3	32.3	699.6	701.75
	<1-5 Years	32.3	32.3	699.8	745.3
	5-10 Years	32.3	32.3	712.6	757.6
	10-15 Years	32.3	32.3	745.2	794
	15-18 Years	32.3	32.3	732	803.3
	>1 Year	33.82	33.95	756.8	756.8
RMC2	<1-5 Years	33.82	33.92	767	825.55
	<5-10 Years	33.82	33.82	756.8	792.2
	<10-15 Years	33.82	33.82	812.8	833.2
	<15-18 Years	33.82	33.82	815.35	853.6
	>1 Year	***65.11***	***65.11***	***1195.48***	***1195.48***

RMC3	***<1-5 Years***	***65.76***	***66.93***	***1327.36***	***1366.97***
	<5-10 Years	***65.11***	***65.76***	***1358.05***	***1415.23***
	<10-15 Years	***69.83***	***70.54***	***1321.16***	***1341.76***
	<15-18 Years	***68.75***	***68.75***	***1405.03***	***1468.47***

There is an iterative reconstruction algorithm "iDose4".At the Palestine Medical Complex (RMC1), Emergency Department, which has a prominent role in reducing the radiation dose. Meanwhile, the radiology technicians at the Palestine Medical Complex, Ramallah Sons Department (RMC2), rely on age group protocols for imaging children's brains.

However, General Electric's CT scan of the Ramallah Sons Department (RMC3), ASiR-free and he Adaptive statistical iterative reconstruction that determines the radiation dose.

These values are also higher than those specified in the report AAPM **(**AAPM, 2015). As shown in Table 4.13.

Table 4.14: Pediatric Head – Routine (Helical) (Selected GE Scanners) (AAPM, 2015).

GE	Optima CT660 w/ASiR	LightSpeed VCT	Discovery CT750 HD	LightSpeed VCT w/ASIR	Discovery CT750 HD w/ASIR
Scan Type	Helical	Helical	Helical	Helical	Helical
Rotation Time (s)	0.8*	0.5*	0.5*	0.5*	0.5*
Detector Configuration	32 x 0.625	32 x 0.625	32 x 0.625	32 x 0.625	32 x 0.625
Pitch	0.531:1	0.531:1	0.531:1	0.531:1	0.531:1
Table Feed/Speed (mm/rot)	10.62	10.62	10.62	10.62	10.62
kV	120	120	120	120	120
Manual mA approach	0-1yr: 40 1-2yrs: 50 2-6yrs: 65 6-16yrs: 85 16+yr: 105	0-1yr: 115 1-2yrs: 140 2-6yrs: 185 6-16yrs: 235 16+yr: 300	0-1yr: 115 1-2yrs: 140 2-6yrs: 185 6-16yrs: 235 16+yr: 300	0-1yr: 80 1-2yrs: 100 2-6yrs: 135 6-16yrs: 170 16+yr: 215	0-1yr: 95 1-2yrs: 120 2-6yrs: 155 6-16yrs: 200 16+yr: 250
Auto-mA approach	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended
SFOV	HEAD	HEAD	HEAD	HEAD	HEAD
ASiR	SS30	no	no	SS30	SS30
CTDI-vol (mGy)	0-1yr: 13.1 1-2yrs: 16.4 2-6yrs: 21.4 6-16yrs: 27.9 16+yr: 34.5	0-1yr: 20.8 1-2yrs: 25.3 2-6yrs: 33.4 6-16yrs: 42.5 16+yr: 54.2	0-1yr: 21.0 1-2yrs: 25.6 2-6yrs: 33.9 6-16yrs: 43.0 16+yr: 54.9	0-1yr: 14.4 1-2yrs: 18.0 2-6yrs: 24.4 6-16yrs: 30.7 16+yr: 38.8	0-1yr: 17.4 1-2yrs: 21.9 2-6yrs: 28.3 6-16yrs: 36.6 16+yr: 45.7

The results showed an increase in the effective dose values to which the patient is exposed during CT scans of the brain in all GHs. As shown as Table 4.13 Compared to values approved by ICRP. As shown as Table 4.14.

Table 4.14. K conversion factor) pediatric brain CT scan) head.

>1 year	1-5 years	5-10 years	10-15 years	15-18 years
0.0011	0.0040	0.0040	0.0032	0.0021

Table 4.15. Evaluate the effective dose for values DLP for Yatta Hospital and Alia GH

Yatta Hospital									
>1 year		1-5 years		5-10 years		10-15 years		15-18 years	
Percentile 75		Percentile 75		Percentile 75		Percentile 75		Percentile 75	
ED	DLP	ED	DLP	ED	DLP	ED	DLP	ED	DLP
1.49	1357.01	6.56	1641.87	6.3	1580.6	5.57	1743.61	3.6	1728.73
Alia Hospital									
>1 year		1-5 years		5-10 years		10-15 years		15-18 years	
Percentile 75		Percentile 75		Percentile 75		Percentile 75		Percentile 75	
ED	DLP	ED	DLP	ED	DLP	ED	DLP	ED	DLP
0.44	401.22	1.76	442.43	2.3	582.72	2.07	649.15	3.6	800.45
Total value at GHs									
>1 year		1-5 years		5-10 years		10-15 years		15-18 years	
Percentile 75		Percentile 75		Percentile 75		Percentile 75		Percentile 75	
ED	DLP	ED	DLP	ED	DLP	ED	DLP	ED	DLP
1.17	1066	4.7	1182	5.1	1276.87	4.16	1303.05	2.9	1383.59

Chapter Five

5.1 Conclusion

This is the first study at the national level to evaluate and compare the dose of CT scans and its effect on children when imaging the brain CT scan.

(Studies have shown a dose-response relationship and the risk of childhood cancer CT).

The study included 11 computed tomography machines, most of which were manufactured by Philips and General Electric, and were used in nine GH_S in Palestine. The study included all children within certain age groups who underwent a CT scan of the brain over three months.

There were 2160 patients in the study, 1406 males and 754 females, and the mean and 75% percentiles of $CTTDI_V$ and DLP values were calculated for age groups >1, <1-5 , < 5-10, <10-15, and < 15-18 years.

The results showed that there were differences in DLP and $CTDI_V$ dose values between CT scanners, which could be mainly attributed to differences in scanning protocols and techniques used and the use of relatively different scanning parameter values (kVp, mAs, scan time, slice thickness, and pitch), which resulted in differential exposure doses for the same CT examinations. Table 4.4.

According to the study, children who underwent brain CT scans at GH_S received higher doses of radiation compared to those in other countries.

DRLS ($CTDI_V$ and DLP for pediatric brain CT scans at GHS (higher doses of radiation).Table 4.8. the radiation dose increases with mAs and kVp. There was a significant increase in scanning time as well, which lengthens the scanning period and raises the radiation dose. Different imaging methods in each hospital and failure to adhere

to the dosing schedule recommended by the manufacturers of CT scanning devices, which were supervised by both the physical engineer and the radiologist. This led to an increase in the dose to the patient and the presence of this large variation in the readings in the CTDI $_V$ radiation dose index from one hospital to another, despite the presence of the same CT machine.(DLP and $CTDI_V$ dose values vary widely between CT scanners).

High DLP values During a CT scan of the brain it led to a noticeable increase in the effective dose values to which the patient is exposed during a CT scan.

Finally, through this study, it was possible to extract the appropriate DRL values when imaging CT scans of children's brains, which was extremely important for radiation protection as it increased knowledge of the doses that were used in the future.

5.2 Recommendations and Future Perspective

The use of adaptive iterative statistical reconstruction calibration is advised. When installing the tomography equipment, ASiR, a logarithmic radiation dose reduction method, is used in GE appliances.

Other applications Filter-back projection, Back projection is employed in Philips's devices through it for iterative reconstruction utilizing reduced dose approaches while retaining image quality.

In addition, it is the iDose4 Hybrid iterative reconstruction approach is one option, when imaging the brain CT scan for the children it provides with good image quality while exposing them to less radiation.

We hope in the future to study computed tomography techniques in government hospitals to significantly reduce the pediatric dose using low-voltage imaging while maintaining image quality based on age groups and depending on weight.

CT manufacturers are now required to provide a dosing schedule showing the doses delivered to patients from their CT machines.

To enhance doses and ensure image quality, we anticipate the Ministry of Health will instruct heads of the tomography departments in government hospitals to review and revise pediatric tomography procedures.

This is accomplished through quality control (QC), which is managed by medical device engineers. Before conducting the tests, it is also advised to do daily calibrations of the tomography devices to improve imaging accuracy and remove artifacts.

This is accomplished by using the technique of setting a phantom with a head size. Exact measurements of the anatomical area to be examined must be determined.
Field of View (FOV), the supraorbital rim, and the inner table of the foramen magnum should form a line parallel to the scanning angle. Through this, it reduces radiation exposure and protects the eyes.

In addition, while imaging children's brains follow the guidelines and protocols created for CT scan machines.

The $CTDI_V$ and DLP values of pediatric brain CT scans at Alia GH can be taken into account as a diagnostic reference levels according to this study.
Low values with quality images. Table 5.1.

Table 5.1: Diagnostic reference levels for Paediatric brain CT scan in Alia Hospital

Alia Hospital									
>1 year		<1-5 years		<5-10 years		<10-15 years		<15-18 years	
Percentile 75		Percentile 75		Percentile 75		Percentile 75		Percentile 75	
CTDIv	**DLP**	**CTDIv**	**DLP**	**CTDIv**	**DLP**	**CTDIv**	**DLP**	**CTDIv**	**DLP**
18.32	401.22	20.09	442.43	21.74	582.72	25.26	649.15	36.38	800.45

5.3 Limitations

This research on local DRLs in the West Bank / Palestine (Government hospitals) was, the first of its kind previous investigations carried out in the West Bank / Palestine were therefore inadequate and lacking in expertise.

Also, the lack of resources, such as the absence of phantom, which was used to build DRLs.

Lack of dose report data (STRADUS) as the values were obtained from a CT scan machines.

We previously identified specific age categories that correspond to weights because CT scan protocols do not include patient weight data.

Moreover, the absence of Jericho Hospital from the study because of the Unavailability of dose report data on the CT system and archiving system for patients are some of the limitations of the research.

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Appendix

Appendix A: AAUP Approval

Arab American University
Faculty of Graduate Studies

الجامعة العربية الأمريكية
كلية الدراسات العليا

28/9/2022

الى من يهمه الأمر.

تسهيل مهمة بحثية

تحية طيبة وبعد،

تهديكم كلية الدراسات العليا في الجامعة العربية الأمريكية أطيب التحيات، وبالإشارة الى الموضوع أعلاه، تشهد كلية الدراسات العليا في الجامعة أن الطالب **اياد عبد الرؤوف سعيد عطية** والذي يحمل الرقم الجامعي**202113186**هو طالب ماجستير في برنامج التصوير المقطعي والتصوير بالرنين المغناطيسي ويعمل على رسالة الماجستير الخاصة به بعنوان:

"تقييم ومقارنة مؤشر جرعة التصوير المقطعي المحوسب لدماغ الأطفال فب المستشفيات الحكومية مع DRL (القياسات العالمية)"

نأمل من حضرتكم الإيعاز لمن يلزم لمساعدته للحصول على المعلومات اللازمة للدراسة، علماً أن المعلومات ستستخدم لغاية البحث فقط وسيتم التعامل معها بغاية السرية، وقد أعطيت هذه الرسالة بناءً على طلبه.

وتفضلوا بقبول فائق الاحترام

عميد كلية الدراسات العليا

د. نوار قطب

كلية الدراسات العليا
FACULTY OF GRADUATE STUDIES

Jenin Tel: +970-4-2418888 Ext.:1471,1472 Fax: +970-4-2510810 P.O. Box:240
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E-mail: FGS@aaup.edu ; PGS@aaup.edu Website: www.aaup.edu

Appendix B: MOH Approval

State of Palestine
Ministry of Health
ation in Health and Scientific
Research Unit

دولة فلسطين
وزارة الصحة
وحدة التعليم الصحي
والبحث العلمي

الرقم: ٢٠٢١/٨٥٣/١٦٤
التاريخ: ٢٠٢١/٤/٢٥

.....
.....

عطوفة الوكيل المساعد لمجمع فلسطين الطبي المحترم،،،
ق. أ. الوكيل المساعد لشؤون المستشفيات والطوارئ المحترم،،،
تحيـة واحتـرام،،،

الموضـــوع: تعديل اسم البحث -تسهيل مهمة بحث

يرجى تسهيل مهمة الطالب: **اياد عبد الرؤوف سعيد عطية – ماجستير برنامج التصوير الطبقي والتصوير بالرنين المغناطيسي**- الجامعة العربية الامريكية، حيث تم تعديل اسم البحث ليصبح بعنوان:

"Assessment and a comparison of pediatric brain CT scan dose index CTDI vol and dose product length (DLP) in governmental hospitals with diagnostic reference level (DRL)"

حيث سيقوم الطالب بجمع معلومات وبيانات الاشعة والجرعات عند تصوير الاطفال، وهذه البيانات هي خاصة بالاجهزة الطبية ولا تخص المرضى، وذلك في:

-مجمع فلسطين الطبي

-جميع المستشفيات الحكومية

مع العلم ان مشرف الدراسة: د. عبد الناصر عاصي
على ان يتم الالتزام بالمحافظة على اخلاقيات البحث العلمي وسرية المعلومات.
على ان يتم تزويد الوزارة بنسخة PDF من نتائج البحث، التعهد بعدم النشر لحين الحصول على موافقة وزارة الصحة.

مع الاحترام،،،

د. عبد الله القواسمي
رئيس وحدة التعليم الصحي والبحث العلمي

نسخة: عميد كلية الدراسات العليا المحترمة/ الجامعة العربية الامريكية

Appendix C: IRP Approval Letter

Arab American University- Palestine
Deanship of Scientific Research
IRB committee
Tel: 04-241-8888, ext 1196
E-mail: irb.aaup@aaup.edu

الجامعة العربية الامريكية- فلسطين
عمادة البحث العلمي
لجنة أخلاقيات البحث العلمي
تلفون: 04-241-8888 ext 1196
البريد الالكتروني: irb.aaup@aaup.edu

IRB Approval Letter

Study Title: Assessment and a comparison of pediatric brain CT scan dose index CTDI vol and dose product length (DLP) in government hospitals with diagnostic reference level (DRL)

Submitted by: Iyad Abd Eraouf saeid Ateiya

Date received: 14th June 2023

Date reviewed: 16th June 2023

Date approved: 16th June 2023

Your Study titled "**Assessment and a comparison of pediatric brain CT scan dose index CTDI vol and dose product length (DLP) in government hospitals with diagnostic reference level (DRL)** " with archived number 2023/A/129/N was reviewed by the Arab American University IRB committee and was approved on 16th June 2023.

Reham Khalaf-Nazzal, MD, PhD
IRB committee chairman
Arab American University of Palestine

General Conditions:

1. Valid for 6 months from the date of approval.
2. It is important to inform the committee with any modification of the approved study protocol.
3. The committee appreciates a copy of the research when accomplished.

لجنة أخلاقيات البحث العلمي في الجامعة العربية الامريكية

IRB at Arab American University

الملخص

المقدمة

يتم إجراء أكثر من 2200 صورة مقطعية لأدمغة الأطفال دون تباين في شهر واحد في المستشفيات الحكومية، وفقًا لبيانات 16 جهازًا للتصوير المقطعي المحوسب في المستشفيات الحكومية في الضفة الغربية، بالإضافة إلى أكثر من 24 جهاز مسح مقطعي آخر في المستشفيات الخاصة بينما يجري مجمع رام الله الطبي ما يعادل 3000 صورة بالأشعة المقطعية شهريًا، بما في ذلك 200 فحص بالأشعة المقطعية على المخ للأطفال دون تباين ، لذلك فإن خطر الإصابة بالسرطان يزداد خطيًا مع جرعة الإشعاع وينخفض تدريجيًا مع تقدم العمر وفقًا لدراسات متعددة، لذا فإن زيادة عدد فحوصات التصوير المقطعي المحوسب للأطفال يمكن أن تزيد من هذا الخطر.

الغرض من هذه الدراسة

هو تقييم مخاطر الإشعاع في طب الأطفال أثناء إجراءات التشخيص بالتصوير المقطعي المحوسب للدماغ في المستشفيات الحكومية من خلال حساب معايير الأشعة لبروتوكولات التصوير (CTDIv&DLP) التي يمكن ملاحظتها في تقارير الجرعة ومقارنتها بتقارير الجرعة الدولية، لأن حماية الأطفال من الإشعاع المؤين في التطبيقات الطبية وخاصة التصوير المقطعي المحوسب لأدمغة الأطفال أمر مهم للغاية، لذلك كان من الضروري قياس جرعة المريض للتحقق من أن جرعة الإشعاع مقبولة من خلال مقارنتها مع DRL المنشور.

طريقة إجراء البحث

تم أخذ عينة بأثر رجعي من أجهزة التصوير المقطعي في المستشفيات الحكومية لجميع مرضى الأطفال الذين خضعوا للتصوير المقطعي للدماغ بدون وسائط تباين بين الفترة 2022/12/1 - 2023/2/31، ثم تم حساب الوسيط والربع الثالث هو متوسط CTDI v وDLP، وقد تم جمع البيانات من أغلب المستشفيات الحكومية للفئات العمرية التالية: <1، 1–5، 5-10، 10-15، 15-18 سنة، ثم مقارنة النتائج التي كانت ذات دلالة إحصائية (p 0.05) مع القياسات الدولية وثم إعطاء النتائج والتوصيات.

النتيجة

كانت القيم الإجمالية CTDI v) و (DLPلجميع المستشفيات الحكومية حسب الفئات العمرية مرتفعة مقارنة ببقية الدول (النسبة المئوية 75٪ ل CTDI v ، 1> سنة = 55.20، 1-5 سنوات = 55.20، 5-10 سنوات = 55.20، 10-15 سنة 55.40، 15-18 سنة = 56.14 ملي غراي. (النسبة المئوية 75٪ ل = DLP أقل من 1 سنة = 1066، 1-5 سنوات = 1182، 5-10 سنوات = 1276.87، 10-15 سنة 1303.05، 15 - 18 سنة = 1383.59 ملي جراي.

الخاتمة

أظهرت النتائج وجود اختلافات في قيم الجرعة DLP وCTDIv في المستشفيات الحكومية (في الضفة الغربية) وايضاً بين أجهزة التصوير المقطعي المحوسب والتي يمكن أن تعزى بشكل أساسي إلى الاختلافات في قيم معلمات CTDIv الاساسية الموجودة على بروتوكولات فحص تصوير الدماغ كما ان فحص البروتوكولات والتقنيات المستخدمة واستخدام قيم معاملات المسح كانت مختلفة نسبيًا (kVp ، mAs وقت المسح ، سمك الشريحة ، وPitch) مما أدى إلى جرعات التعرض التفاضلية لنفس فحوصات التصوير المقطعي المحوسب ، ووفقًا للدراسة ، فإن الأطفال الذين خضعوا لفحص الأشعة المقطعية للدماغ في المستشفيات الحكومية يتلقون جرعات إشعاعية أعلى من تلك الموجودة في البلدان الأخرى كما لوحظ أيضًا اختلاف كبير في مؤشر جرعة الإشعاع CTDI v من مستشفى إلى آخر على الرغم من وجود نفس نوع ومواصفات جهاز التصوير .