**EAS Journal of Radiology and Imaging Technology**
*Abbreviated Key Title: EAS J Radiol Imaging Technol*
ISSN: 2663-1008 (Print) & ISSN: 2663-7340 (Online)
Published By East African Scholars Publisher, Kenya

OPEN ACCESS

Volume-6 | Issue-2 | Mar-Apr-2024 | DOI: 10.36349/easjrit.2024.v06i02.004

**Original Research Article**

# Exposure to Ionizing Radiation from Initial Brain Computed Tomography for Injuries in the South-West Region of Cameroon

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**Article History**
Received: 01.03.2024
Accepted: 07.04.2024
Published: 13.04.2024

**Journal homepage:**
https://www.easpublisher.com

**Quick Response Code**

**Abstract:** The increasing use of computed tomography (CT) in injury management is a growing concern as ionizing radiation (IR) is associated with cancer-related risks especially in young persons, who are most affected by injuries. This study aimed to assess ionizing radiation exposure from head CT in patients with injuries and to propose CT dose age-specific diagnostic reference levels (DRLs). Data was extracted from two prospectively collected CT registries over a period of 5 years at two community-based university-affiliated hospitals from 2019 to 2024. The linear relationship between CT dose (dose-length product; DLP) and age was assessed using Pearson's correlation whilst linear regression was used to determine the strength of the relationship. The 75$^{th}$ percentiles and 95% confidence intervals (CIs) of the DLP were determined. Eligible initial head CT scans for patients with injuries were 1,155. There were 685 (59.31%) males (sex ratio of 1.5:1) and overall median age of 33 years (interquartile range: 21 to 46). Road traffic injuries were the source of injury in 1090 individuals (94.37%; 95% CI: 92.88 - 95.63%), followed by falls (50 cases; 4.33%; 95% CI: 3.23 - 5.67%) and assaults (10 cases; 0.87%; 95% CI: 0.42 – 1.59). The median DLP was 1,062 mGy.cm (range: 264 to 1,954 mGy.cm). There was a positive linear relationship between the DLP and the age of the patients (*Pearson's rho* = 0.38, p<0.001). DRLs were comparable to international values. Measures to curb the rising incidence of injuries and the continuous implementation of CT optimization techniques will reduce IR exposure.

**Keywords:** Ionizing radiation, computed tomography, head injury, diagnostic reference levels.



## INTRODUCTION

Medical exposure to ionizing radiation accounts for about 48% of all exposure to ionizing radiation (UNSCEAR, 2011). Of the medical sources of exposure to IR, computed tomography accounts for close to half of this (Kalender, 2014; Meulepas *et al.*, 2019). The use of CT has increased worldwide attributable to many factors including increasing accessibility, availability, affordability, expanded clinical indications, enthusiasm to use new technology and defensive medical practice (Hendee *et al.*, 2010; Salerno *et al.*, 2019). CT remains the imaging workhorse of hospital emergency departments and some authors report as many as 8.2 to 13.7% of all patients who present at the ED receive CT (Bhayana *et al.*, 2014; Worrall *et al.*, 2014).

In Cameroon, CT requests most of the time are to assess patients with injuries, stroke and other neurologic symptoms, and lower back pain, with the head region accounting for over 50% of all scans performed (Tambe, Mbuagbaw, Nguefack-Tsague, *et al.*, 2020; Tambe, Mbuagbaw, Ongolo-Zogo, *et al.*, 2020). The burden of head and facial injuries is therefore considerable and more frequent among adolescents and young adults who are more likely to die or experience significant disability (James *et al.*, 2018; Laytin & Debebe, 2019). These injuries arise from road traffic accidents, assaults and domestic injuries (Chichom-Mefire *et al.*, 2017). Many of these patients with injuries will require some form of imaging for diagnosis or follow-up of lesions. Data from the Cameroon Trauma Registry showed that from 2017 to 2019, 3,556 trauma patients out of 9635 received medical imaging studies of

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which conventional radiography accounted for 87.3% and CT 10.5% (Driban *et al*., 2023).

There is an overall increase in the use of ionizing radiation from CT in trauma patients, most of whom are young (Sharma *et al.*, 2011). IR exposure from CT is a growing cause for concern due to cancer-related risks (Brenner & Hall, 2007). This risk is higher in young persons, and even though small at the individual level, has the potential to lead to more cases of cancer in the population over time as more persons get exposed (Mathews *et al*., 2013; Shao *et al.*, 2020). This study aspired to assess the radiation exposure from initial head CT scans in people with injury in two community-based hospitals in the South-West Region of Cameroon.

# MATERIAL AND METHODS

We extracted data from a prospectively collected CT registry for a period of 5 years (March 2019 to March 2024). The CT registries of two university-affiliated hospitals in the South-West Region of Cameroon were used, and these hospitals were Limbe and Buea Regional Hospitals. These hospitals are intermediate-level referral health facilities with a capacity each of about 150 beds, and located some 18miles from each other. Both facilities have a 16-slice CT scanner, HITACHI SUPRIA® and SIEMENS GO.NOW® that have been in service for 7 years and 1 year respectively. Ethical clearance for the study was waived given that data was extracted from a hospital-based registry.

Head CT scans indicated for "injury" or "trauma" were selected for the study. Repeat studies were not eligible. In the absence of specific medical record numbers for clients the name, sex and date of birth were used to determine if studies belonged to the same individual. A standardized data extraction form was created on a Microsoft Excel® spreadsheet with variables of interest being the age of the patient, the sex, the type of injury, and the CT dose-length product (DLP). Two medical imaging technologists trained as research assistants extracted data from each site.

Data from the Excel spreadsheet were imported and analyzed with the statistical software STATA 12MP® (STATACORPS, TEXAS, USA). Categorical variables were summarized as counts and percentages with 95% confidence intervals (CI) while continuous variables were summarized using the mean and median. *Pearsons rho* was used to assess for any linear relationship between CT dose and the age of patients, and a scatterplot was used to provide a graphical representation. Linear regression was used to compare average CT doses per age group and the threshold for statistical significance was set at 0.05. Diagnostic reference levels for CT doses were determined based on age groups, and consisted of the 75$^{th}$ percentile of the CT dose-length product (DLP) and its corresponding 95% confidence interval (CI).

# RESULTS

***Demographic characteristics of the patients***

A total of 1,155 eligible initial head CT scans for patients with head injuries were selected. There were 685 (59.31%) males and a sex ratio of 1.5:1. The mean age was 33.75 ± 18.07 years, and median age 33 years (interquartile range: 21 to 46). The age distribution is presented in Figure 1.

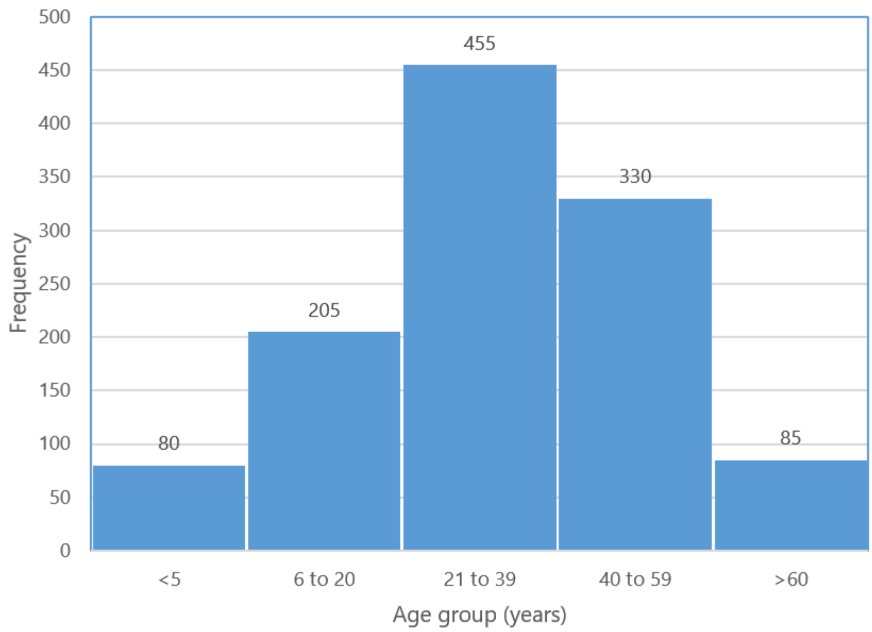


**Figure 1: Age group distribution of the patients with initial head CT in patients with injury**

***Type of injuries***

Road traffic injuries were the source of injury in 1090 individuals (94.37%; 95% confidence interval [CI]: 92.88 - 95.63%), followed by falls (50; 4.33%; 95% CI: 3.23 - 5.67%) and assaults (10; 0.87%; 95% CI: 0.42–1.59).

***CT dose***

The mean DLP was 1021.75 ± 260.69 mGy.cm and median 1,062 mGy.cm (range: 264 to 1,954 mGy.cm). There was a positive linear relationship between the DLP and the age of the patients (Pearson's rho = 0.38). This linear relationship was statistically significant in the linear regression analysis ($p<0.001$). Figures 2 and 3 illustrate the relationship between DLP and age. The linear relationship between DLP and age was similar for males and females.

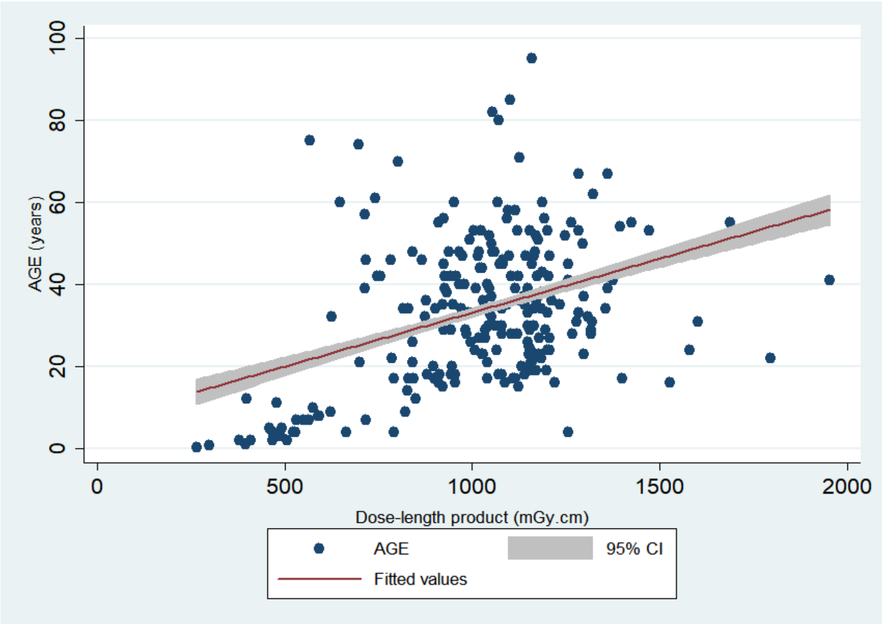


**Figure 2: Relationship between DLP from initial head CT in patients with injury and age**

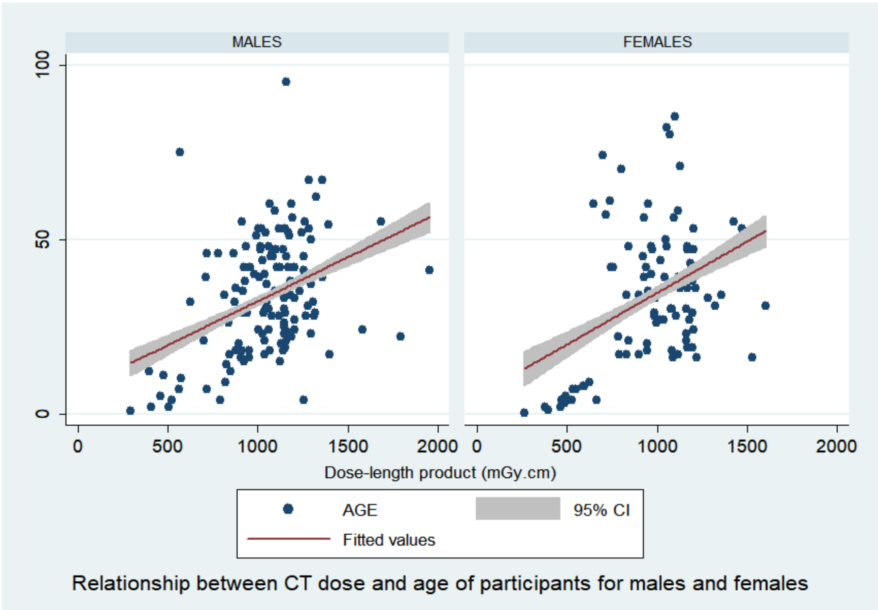


**Figure 3: Relationship between DLP and age for males and females**

The median DLP was compared amongst the different age groups and the strength of the association determined using the beta coefficient. The 75$^{th}$ percentile of the DLP and its corresponding 95% confidence interval was calculated per age group to ascertain a diagnostic reference level. The findings are presented in Table 1. Figure 4 shows a graphical representation of the distribution of DLPs and age groups.

**Table 1: Median DLP per age group and diagnostic reference levels**

| Age group (years) | Median DLP (25-75th percentile) (mGy.cm) | Beta regression coefficient | P value | DRL (75th percentile ± 95% CI) (mGy.cm) |
|---|---|---|---|---|
| ≤5 | 478.5 (401.5 – 524.5) | Ref | Ref | 524.5 ± 49.65 |
| 6 to 20 | 912 (792 – 1,108) | 0.57 | <0.001 | 1,108 ± 34.48 |
| 21 to 39 | 1,120 (1,007 – 1,185) | 1.09 | <0.001 | 1,185 ± 16.7 |
| 40 to 59 | 1,088.5 (975 - 1,192) | 1.00 | <0.001 | 1,192 ± 22.44 |
| ≥60 | 1,071 (802 – 1,158) | 0.49 | <0.001 | 1,158 ± 49.96 |

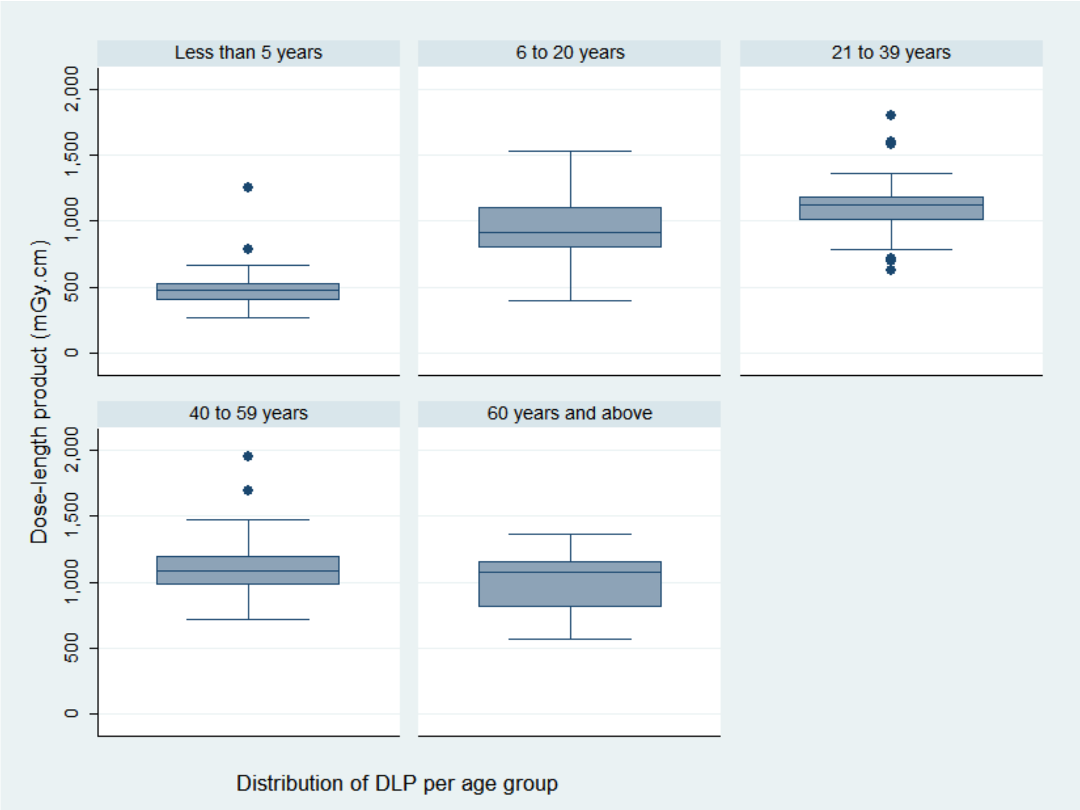


**Figure 4: Summary frequency distribution of DLPs per age group**

## DISCUSSION

The burden of head injury is high among young people, with the 21 to 39 years age group accounting for the majority of cases. The number of cases considerable decreased on either side of this modal age group. In addition, more males than females required imaging for head injury. Salibi *et al*., reported that a 34-year-old man was a typical patient to suffer a severe head injury that would requiring imaging with CT scan (Salibi *et al*., 2014). Injuries mostly affect young male adults with high-risk behaviors and hobbies identified as predisposing factors (Chichom-Mefire *et al*., 2017).

CT is a fast, accurate and reliable tool in trauma imaging, accounting for as much as 80% of all imaging studies performed (Bågenholm *et al*., 2020; Leeson *et al*., 2015). However, ionizing radiation is a major concern in the imaging of trauma patients, especially if multiple body regions or repeat scans are performed (Bos *et al*., 2022; Linder *et al*., 2016). Cancer is the major risk from ionizing radiation use. Despite the relatively low doses in diagnostic imaging, some authors have reported a non-negligible cancer risk especially for pediatric patients and adolescents (Bos *et al*., 2022; Mathews *et al*., 2013; Meulepas *et al*., 2019). Specifically for head CT from injuries, some authors did not report any significant lifetime attributable risk of cancer (Salibi *et al*., 2014).

In this study there was a significant difference in the DLPs in children 5 years and less compared to all patients above 5 years. The 75th percentile of the DLP was considerably lower in children 5 years and below, and corresponded to some internationally reported values (Bos *et al*., 2022). Some authors had earlier reported local diagnostic reference values for head CT scans in different regions of Cameroon (Kamdem *et al*., 2022; Moifo *et al*., 2017). There are remarkable variations in reported ranges, and these variations have been reported across continents and countries (Bos *et al*., 2022).

Given the potential risks of ionizing radiation and yet the immense benefits of using CT in trauma patients when indicated, the watchword therefore becomes caution. CT should be used appropriately and not replace thorough clinical assessment (Hui *et al*., 2009). In children less than 5 years old radiation doses have been reported by some authors to be high, and clinical monitoring should therefore be given priority as this can reduce the number of repeat scans (Dogan *et al*., 2023). Nevertheless, phobia for ionizing radiation should not hinder its use as some authors reported that early mortality in trauma patients was linked to not receiving an imaging study (Driban *et al*., 2023).

Furthermore, to minimize CT dose, several optimization techniques can be used. These include reducing tube voltage for low body weight patients, using automatic current modulation, single-phase instead of two-phase scans, using soft convolutional kernel, and replacing repeat CT with non-ionizing alternatives such as ultrasonography and MRI (Kim *et al*., 2011).

Comprehensive care for injured patients require a multi-disciplinary team with established protocols and regular updates (Christie *et al*., 2023). This will enable prompt and appropriate action, especially with respect to imaging to ensure that patients get required imaging assessment for diagnosis and follow-up.

**Conflict of Interest**: The authors declare no competing interest

**Funding**: None

**Acknowledgments**: The authors thank Mrs. Arabella Tambe, BA, MEd, for proofreading the manuscript

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**Cite This Article:** Joshua Tambe, Yannick Onana, Sylviane Dongmo, Alain Chichom, Emilienne Guegang, Pierre Ongolo-Zogo, Boniface Moifo, Odile F. Zeh (2024). Exposure to Ionizing Radiation from Initial Brain Computed Tomography for Injuries in the South-West Region of Cameroon. *EAS J Radiol Imaging Technol*, *6*(2), 23-28.