2026 International Nuclear Atlantic Conference – INAC 2026
Escola de Guerra Naval, Rio de Janeiro, RJ, August 24 - 28, 2026

Comparative Analysis for Dose Optimization in Cranial Computed Tomography in Compliance with ANVISA's RDC 611/2022

Xavier, P. R.[1]; Freitas, G. R.[2];
Souza, C. D.[3]; Oliveira, R. A.[4]

[1] *p.xavier@unesp.br,* [4] rogerio.oliveira@unesp.br,
Institute of Biosciences, São Paulo State University (UNESP), 1860 Prof. Dr. Antônio Celso Wagner Zanin Street, Botucatu, São Paulo 18618-689, Brazil.
[2] *gustavo.f@ipen.br,* [3] cdsouza.ipen.br,
Nuclear and Energy Research Institute (IPEN), 2242 Professor Lineu Prestes Avenue, São Paulo, São Paulo 05508-000, Brazil.

1. Introduction

Technological advancements have consolidated Computed Tomography (CT) as an indispensable tool for medical diagnosis due to its high spatial resolution. However, the high frequency of cranial scans in hospital routines raises a critical alert regarding ionizing radiation doses and potential biological damage. In line with international radioprotection guidelines, the Brazilian National Health Surveillance Agency (ANVISA) established Resolution RDC No. 611/2022 [1], which mandates dose monitoring to ensure diagnostic practices operate under the ALARA (As Low As Reasonably Achievable) principle. This study presents a robust retrospective analysis of a historical database (2021–2023) from the Cotia Regional Hospital, evaluating the compliance of cranial scan dose levels using computational biostatistics, aiming at radiological optimization with a primary focus on patient safety. The optimization of protocols in radiodiagnostics is a fundamental pillar of contemporary radiation protection. The publication of the Board Resolution RDC No. 611/2022 [1] and the Normative Instruction IN No. 93/2022 [2] by ANVISA established strict criteria and Diagnostic Reference Levels (DRLs) to ensure that radiation doses delivered to patients are as low as reasonably achievable for the expected clinical benefit [3].
In this scenario, the integration of computational biostatistics emerges as a strategic pillar. The robust retrospective audit of large historical hospital databases allows not only mapping the actual dosimetric scenario of the institution but also identifying operational discrepancies. This approach ensures the reproducibility of clinical protocols and enhances the safety of individuals exposed to radiation. This undergraduate research project aimed to:

- Evaluate the compliance of radiation doses applied in individual cranial CT scans at the Cotia Regional Hospital against the regulatory limits of ANVISA's RDC 611/2022 [1], using the Dose-Length Product (DLP, measured in mGy·cm) as the reference metric;
- Demographically stratify the dosimetric parameters, mapping dose behavior and variability by crossing biological sex and specific age groups;
- Apply computational statistical inference models to accurately determine the central tendency and the precision (confidence intervals) of each analyzed subgroup, serving as a baseline for local technical protocol optimization.

2. Methodology

A retrospective study was conducted based on historical dosimetric data collected from 2021 to 2023, originating from individual cranial CT scans performed at the Cotia Regional Hospital (Cotia/SP) using a 16-slice GE Medical Systems scanner (Revolution ACT). Only procedures containing complete records of the physical quantity Dose-Length Product (DLP) were selected for the study.

The dataset was simultaneously stratified by biological sex and categorized into five specific age groups: 0 to 6 years, 7 to 12 years, 13 to 17 years, 18 to 59 years (Adults), and 60+ years (Elderly). Inferential statistical modeling was performed using the scipy.stats library in a Python 3 environment. Central tendency metrics were calculated to characterize each subgroup's distribution: Mean ($\bar{X}$), Median ($\tilde{X}$), and Mode (Mo). Finally, to measure the precision of the estimates against sample variation among the groups, the Student's t-distribution was used to determine the 95% Confidence Interval (CI) for the mean dose of each population stratum, according to the fundamental equation (Eq.1):

$$CI = \bar{X} \pm t_{\alpha/2,\, n-1} \times (S / \sqrt{n}) \quad (1)$$

The Adult and Elderly groups concentrated the largest portion of the hospital sample. Due to this robust volume of data, the 95% Confidence Intervals were extremely narrow, indicating high statistical precision and stability in the estimated mean dosimetric values because of the low standard error. Conversely, the pediatric groups, having a smaller volume of data, exhibited wider confidence intervals (larger error bars). The application of the Student's t-distribution was indispensable to correctly adjust for the statistical bias of these reduced sample sizes.

Regarding legal compliance, all central tendency metrics calculated for cranial CT scans in adults and the elderly were substantially below the national benchmark limit established by ANVISA's Normative Instruction IN No. 93/2022 (1050 mGy·cm) [2], proving the radiological safety of the service. The divergence between the Mean and Median in some scenarios reflects isolated exams with atypical doses (technical outliers). However, the strong proximity and equivalence of the Medians between sexes within each age group demonstrate excellent standardization and reproducibility in the image acquisition protocols employed by the hospital. Table 1 present the results.

Table 1: Descriptive dosimetric parameters and stratified sample sizes at the Cotia Regional Hospital (2021–2023).

Age Group	Biological Sex	Sample Size (n)	Mean DLP (mGy·cm)	Median DLP (mGy·cm)	Mode DLP (mGy·cm)	ANVISA DRL Limit
0 to 6 years	Female	894	389.9	254.0	0.0	-
0 to 6 years	Male	1,343	408.0	328.4	679.4	-
7 to 12 years	Female	619	456.6	429.9	785.1	-
7 to 12 years	Male	977	457.1	418.9	806.6	-
13 to 17 years	Female	963	484.9	447.0	0.0	-
13 to 17 years	Male	1,18	487.9	480.0	0.0	-
18 to 59 years	Female	19,116	475.7	397.3	0.0	1050 mGy·cm
18 to 59 years	Male	25,708	491.6	409.5	0.0	1050 mGy·cm
60+ years	Female	12,913	421.9	364.7	0.0	1050 mGy·cm
60+ years	Male	13,301	452.4	389.2	0.0	1050 mGy·cm

3. Results and Discussion

The Adult and Elderly groups concentrated the largest portion of the hospital sample. Due to this robust volume of data, the 95% Confidence Intervals were extremely narrow, indicating high statistical precision and stability in the estimated mean dosimetric values because of the low standard error. Conversely, the pediatric groups, having a smaller volume of data, exhibited wider confidence intervals (larger error bars). The application of the Student's t-distribution was indispensable to correctly adjust for the statistical bias of these reduced sample sizes.

Regarding legal compliance, all central tendency metrics calculated for cranial CT scans in adults and the elderly were substantially below the national benchmark limit established by ANVISA's Normative Instruction IN No. 93/2022 (1050 mGy·cm) [2], proving the radiological safety of the service. The divergence between the Mean and Median in some scenarios reflects isolated exams with atypical doses (technical outliers). However, the strong proximity and equivalence of the Medians between sexes within

each age group demonstrate excellent standardization and reproducibility in the image acquisition protocols employed by the hospital.

4. Conclusions

The utilization of Python 3 proved to be a highly efficient and scalable computational solution for large-scale data screening, pediatric age normalization, and statistical processing in hospital environments. The results obtained unequivocally confirm the radiological safety and full compliance of the Cotia Regional Hospital regarding current ANVISA regulations for the adult and elderly populations, presenting dose levels well below the regulatory caps. The symmetrical behavior between sexes highlights the high standard of local execution, offering a solid database for the maintenance of quality assurance programs and continuous optimization.

References

[1] Brazilian Health Regulatory Agency (ANVISA), "Resolution of the Board of Directors – RDC No. 611, of March 9, 2022," https://www.in.gov.br/en/web/dou/-/resolucao-da-diretoria-colegiada-rdc-n-611-de-9-de-marco-de-2022-385558113 (2022).

[2] Brazilian Health Regulatory Agency (ANVISA), "Normative Instruction – IN No. 93, of March 9, 2022," https://www.in.gov.br/en/web/dou/-/instrucao-normativa-in-n-93-de-9-de-marco-de-2022-385558114 (2022).

[3] International Commission on Radiological Protection (ICRP), "Diagnostic Reference Levels in Medical Imaging," *Annals of the ICRP*, vol. 46, no. 1, pp. 1–144 (2017). Available at: https://www.icrp.org/publication.asp?id=ICRP%20Publication%20135.