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Justification of Medical Exposures to Ionizing Radiation

Justificação das Exposições Médicas a Radiação Ionizante

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Abstract

The increasing use of radiological examinations involving ionizing radiation raises concerns regarding their clinical justification, particularly in light of the projected rise in cancers associated with such procedures. The primary objective of this study was to assess the adequacy of the clinical context field in radiological exam requests, in accordance with the recommendations outlined in the "Manual de Boas Práticas de Radiologia" and Law 108/2018, which establishes the principle of justification for medical exposures.
A cross-sectional analytical observational study was conducted within a "Unidade Local de Saúde", encompassing three hospital facilities. The sample consisted of 400 exam requests randomly selected in 2025 and reviewed by two Radiation Protection Officers. The requests were classified using the RI-RADS system, which evaluates the quality of the clinical information provided.
Results showed that only 4% of the requests were classified as RI-RADS A (adequate), while 68% were deemed deficient (RI-RADS D). A statistically significant association was found between the quality of the request and both the imaging modality and the origin of the prescription, with the poorest results observed in plain radiography and in the emergency service.
The study concludes that there is an urgent need to improve the prescription process by promoting professional training and revising request templates. The implementation of corrective measures may contribute to a safer and more effective radiological practice, aligned with best practice standards, ensuring better patient care and a more rational use of healthcare resources.

Keywords

Radiological protection; justification; RI-RADS.

Resumo

A crescente utilização de exames radiológicos com recurso a radiação ionizante levanta preocupações quanto à sua justificação clínica, especialmente face ao aumento projetado de cancros associados. Este estudo teve como objetivo principal avaliar a adequação do preenchimento do campo relativo ao contexto clínico nas requisições de exames radiológicos, conforme as recomendações do Manual de Boas Práticas de Radiologia da Ordem dos Médicos e o Decreto-Lei n.º 108/2018, que estabelece o princípio da justificação das exposições médicas.
Foi realizado um estudo observacional analítico transversal numa Unidade Local de Saúde, envolvendo três unidades hospitalares. A amostra incluiu 400 requisições selecionadas aleatoriamente em 2025, analisadas por dois Delegados de Proteção Radiológica. As requisições foram classificadas segundo o sistema RI-RADS, que avalia a qualidade da informação clínica fornecida.
Os resultados revelaram que apenas 4% das requisições foram classificadas como RI-RADS A (adequadas), enquanto 68% foram consideradas deficientes (RI-RADS D). Verificou-se associação estatisticamente significativa entre a qualidade da informação e a modalidade do exame, bem como a proveniência da prescrição, com destaque para os piores resultados na Radiologia Convencional e no Serviço de Urgência.
Conclui-se que existe uma necessidade urgente de melhorar o processo de prescrição, promovendo a formação dos profissionais e a revisão dos modelos de requisição. A implementação de medidas corretivas poderá contribuir para uma prática radiológica mais segura, eficaz e alinhada com os padrões de boas práticas, garantindo melhores cuidados ao utente e uma utilização mais racional dos recursos em saúde.

Palavras-chave

Proteção radiológica; Justificação; RI-RADS.

Introduction

The concept of "clinical audit," found in the legal framework for radiation protection,[1] is understood as a systematic process of analysing medical radiological procedures with the aim of improving the quality of patient care. This process should be based on a comparison between clinical practices and best practice standards, promoting changes when necessary.
The European Commission's guidelines on clinical audits for medical radiological practices are summarized in Radiation Protection No. 159[2] and Radiation Protection No. 198.[3] Their analysis clearly demonstrates that it consists of a process of fact-finding and interpretation, enabling efficient monitoring and improvement of the quality of medical practices. It generally has the dual function of assessing the current state of the healthcare facility regarding the care provided and identifying areas for future improvement. Clinical auditing should be viewed as part of a continuous learning process to introduce personal and professional improvements.
In recent decades, patient exposure to radiation has increased considerably.[4,5]

The number of computed tomography (CT) scans relative to population size increased in almost all EU countries: between 2012 and 2022, almost all EU countries saw an increase in the number of CT scans performed in relation to their respective population sizes; the only exceptions were Cyprus and Denmark. The largest increases were recorded in Portugal, Latvia, and Lithuania.[5]

Older studies indicate that between 1% and 2% of cancers in European countries may be related to exposure to ionizing radiation in general (medicinal and environmental).[6,7] More robust and current data estimate that, if we continue at this rate, cancers associated with CT scans may eventually account for 5% of all new cancer diagnoses annually.[8]

This raises the question of justification, a new dimension that is important not to overlook.

The aim of this study is to verify compliance with the recommendations of scientific societies and health authorities[9] regarding the justification of medical exposures, reinforcing the importance of patient radiation protection to minimize associated risks while ensuring the potential benefits of ionizing radiation.

The main objective of this study was to assess how appropriately the field regarding the clinical context that motivated the examination request was being filled out, in accordance with the guidelines of the Portuguese College of Medicine, as set out in the Manual of Good Practices for the Radiology Specialty. This analysis aims to ensure compliance with the provisions of Law No. 108/2018, as currently worded, particularly regarding the principle of justification. This principle establishes that medical exposure must offer a real and sufficient benefit, weighing the potential gains in terms of diagnosis or therapy—both for individual health and for society—against the harm that such exposure may cause. Such consideration must contemplate the effectiveness, benefits and risks of available alternative techniques that fulfil the same purpose but involve less or no exposure to ionizing radiation.

It further stipulates that all individual medical exposures must be justified in advance, taking into account the specific objectives of the exposure and the characteristics of the individual in question. Healthcare professionals responsible for prescribing and administering medical exposures should, whenever possible, seek prior diagnostic information or relevant medical records and analyse these data to avoid unnecessary exposures.

Additionally, the study sought to identify potential significant differences or common patterns in exam prescriptions, considering the modality used, the location where the exposure took place and the originating unit—whether emergency room, hospital consultation, inpatient care or primary care.

In the future, this study aims to play a significant role in the continuous improvement of healthcare, contributing to the generation of data that can be compared with other Local Health Units (LHU), enabling a more comprehensive and integrated analysis of the national clinical reality. Simultaneously, it aims to produce indicators that allow comparisons before and after the eventual implementation of corrective measures, permitting the assessment of their effectiveness and actual impact on clinical practice.

Through this approach, the aim is to maximize the effectiveness of clinical care, promoting a more efficient response focused on the patient's needs. The study also aims to improve the quality of care provided and its health outcomes, ensuring that each intervention contributes significantly to the individual's well-being.

Another fundamental purpose is to minimize and prevent harm, not only at the individual level but also in the broader context of society, strengthening safety and responsibility in medical practice. Promoting the effective use of available resources is also crucial, ensuring that technical and human resources are applied rationally and sustainably.

Materials and Methods

The study was conducted in July 2025 at Local Health Unit Médio Tejo, which comprises three hospital units, Tomar (Unit 1), Torres Novas (Unit 2) and Abrantes (Unit 3) all equipped with a radiology service.

Type of study:

Considering the objective, a cross-sectional, analytical observational study was developed.

Population:

In the context of the study, the population considered at the audited LHU consisted of requests existing in the hospital database for radiological examinations already performed and in the archives.

All requests for CT and mammography examinations were evaluated by a radiologist before their execution, and the results included the corresponding medical report. In contrast, in Conventional Radiology, regardless of their origin, none of the requests were evaluated by a radiologist; the analysis of the results was performed exclusively by the prescribing physician.

CT requests made at Hospital Unit 3 were excluded because this service is operated by an outsourcer. Although the quality of clinical information in the examination request must comply with the same good practices, it was decided not to consider these requests due to the difficulty in accessing the information.

Data collection procedure:

Data were randomly collected from the hospital database, with a sample of 400 requests, with a distribution according to Table 1. The audit team was composed of 2 Radiographers, a role they combine with the position of Radiation Protection Officers, duly recognized by the regulatory entity and appointed by the institution.

Table 1 – Distribution of requests by modality, origin and Hospital Unit (own source)

Modality	Origin	Hospital Unit			TOTAL
		3	1	2	
Conventional Radiology	Emergency	20	20	20	240
	Consultation	20	20	20	
	Inpatient	20	20	20	
	Primary Care	20	20	20	
CT	Emergency	-	-	-	120
	Consultation	-	20	20	
	Inpatient	-	20	20	
	Primary Care	-	20	20	
Mammography	Consultation	-	-	20	40
	Primary Care	-	-	20	
					400

The completion of the field relating to the clinical context that led to the examination request was evaluated, in accordance with the recommendation of the Portuguese College of Medicine, in its Manual of Good Practices for the Radiology Specialty 10, as shown in Table 2:

Table 2 – Description of the RI-RADS classification, adapted from the Manual of Good Practices for the Radiology Specialty of the Portuguese College of Medicine (2024)

GRADE	DESCRIPTION	Clinical information included in the request
RI-RADS A	Adequate	All key categories of information included..
RI-RADS B	Vaguely adequate	All key categories of information included; some clinical findings missing.
RI-RADS C	Considerably limited	Two categories of information included.
RI-RADS D	Inadequate	None or only one category of information included. .

Key categories of information for the RI-RADS Grading:
1 - Impression: provisional or differential diagnoses
2 - Clinical findings:
- signs and symptoms
- chronicity of the current episode
- location of symptoms
- relevant previous medical-surgical history (including contraindications to the use of contrast, presence of medical devices that may compromise the safety of the exam, personal/family history)
- relevant laboratory findings
- relevant previous imaging information

3 - Diagnostic question: rule out/confirm a specific diagnosis; staging; follow-up; assessment of progression or response to therapy; image-guided operative navigation.

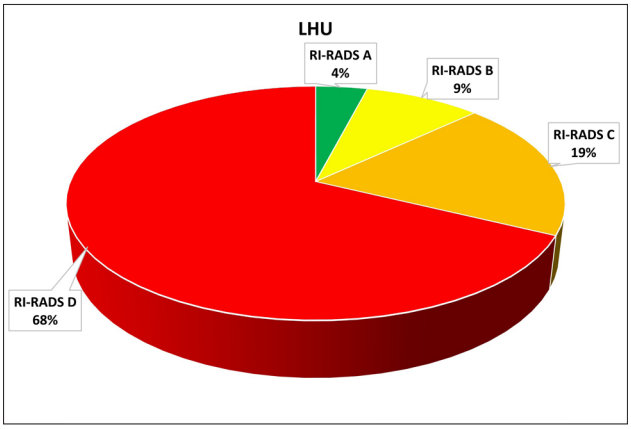
This information must be available at the time of scheduling the exams and be available to both the Radiologist and the Radiology Technician.[10]

Data analysis:
Data analysis was performed using IBM SPSS Statistics 29 software. Nonparametric inferential statistics (chi-square test and Fisher's exact test) were calculated to characterize the study population, stratified by groups (Conventional Radiology, Mammography, CT) and (Emergency, Inpatient, Consultation and Primary Care).
Fisher's exact test was used to assess the association between the "local" group and the classification categories (RI-RADS A, B, C, and D). This test was chosen due to the presence of zero count cells in the contingency table.
The chi-square test was used to assess the association between the RI-RADS classification and the "origin" and "modality" groups.
Descriptive statistics were also used to analyse the entire sample.

Ethical considerations:
Ethical issues were considered, and the study received a favourable opinion from the Health Ethics Committee (technical opinion no. 23/25).

Results
The quality of the clinical context field information in the 400 radiology exam requests was analysed using the RI-RADS classification system.

Overview
Graph 1 shows the overall distribution of RI-RADS classifications for the entire sample, regardless of modality, hospital unit or prescription source.
The most favourable classifications, RI-RADS A (Adequate) and RI-RADS B (Variably adequate), were the least frequent (n=52/400 requests).
The majority of requests (n=271/400) were classified in the most unfavourable category, RI-RADS D (Inadequate).



Graph 1 – RI-RADS classification considering all modalities, all hospital units, and all prescription origins (own source).

Results by Modality
Table 3 details the RI-RADS classifications by examination modality, Hospital Unit and prescription origin.

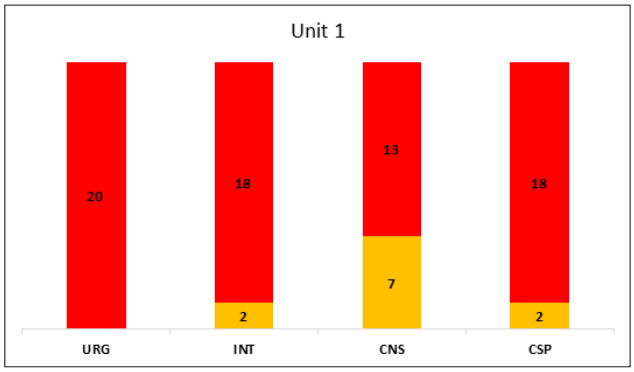
Conventional Radiology
In the Conventional Radiology modality (n=240/400), the trend towards inadequate information was more pronounced, with 88% (n=211/240) of prescriptions classified as RI-RADS D. No prescription in this modality was classified as RI-RADS A and only 1.3% (n=3/240) was classified as RI-RADS B.
Being the only modality transversal to the three Hospital Units, the distribution of classifications demonstrated similar patterns in Units 1, 2 and 3 (Graphs 2, 3 and 4, respectively). Hospital Unit 3 presented the worst result, with 92.5% of the exams (n=74/80) classified as RI-RADS D.

Computed Tomography (CT)
In Computed Tomography (CT) (n=120/400), the distribution of classifications showed a slight improvement, with 10.8% (n=13/120) of exams classified as RI-RADS A. However, the RI-RADS D classification still represented a significant portion, reaching 35.8% (n=43/120) of exams.
The distribution of classifications in Hospital Units 1 and 2 (Graphs 5 and 6) demonstrated a similar pattern, with slightly more favourable results in Hospital Unit 2.

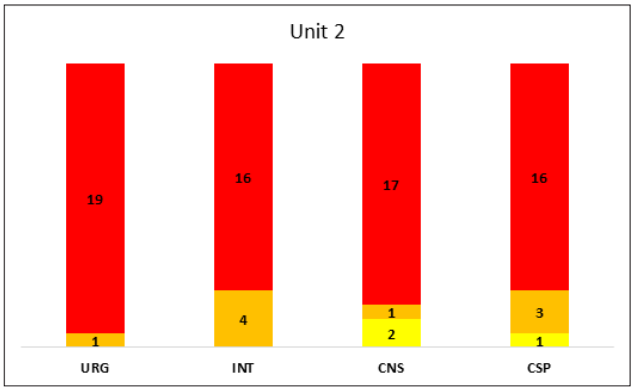
Mammography
Mammography (n=40/400), performed only at Hospital Unit 2, was distributed across all RI-RADS categories (Graph 7).
The RI-RADS D classification was dominant, representing 42.5% of exams (n=17/40). The remaining classifications were distributed as follows: 7.5% RI-RADS A (n=3/40), 17.5% RI-RADS B (n=7/40), and 32.5% RI-RADS C (n=13/40).
Hospital consultations presented better classifications, with 50.0% RI-RADS A and B (n=10/20) and none RI-RADS

Table 3 – RI-RADS classifications by modality, hospital unit and origin (own source).

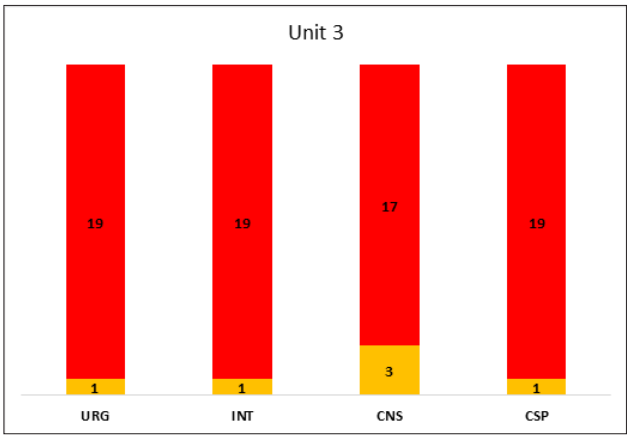
			RI-RADS						
Modality	**Hospital Unit**	**Origin**	**A**	**B**	**C**	**D**	**Total**		
Conventional Radiology	1	Emergency Consultation Inpatient Primary care	- - - -	- - - -	- 7 2 2	20 13 18 18	20 20 20 20	80 (20%)	240 (60%)
	2	Emergency Consultation Inpatient Primary care	- - - -	- 2 - 1	1 1 4 3	19 17 16 16	20 20 20 20	80 (20%)	
	3	Emergency	-	-	1	19	20	80 (20%)	
		Consultation Inpatient Primary care	- - -	- - -	3 1 1	17 19 19	20 20 20		
CT	1	Consultation Inpatient Primary care	1 6 -	6 4 1	6 7 6	7 3 13	20 20 20	60 (15%)	120 (30%)
	2	Consultation Inpatient Primary care	- 6 -	3 7 5	10 6 3	7 1 12	20 20 20	60 (15%)	
Mammography	2	Consultation Primary care	3 -	7 -	10 3	- 17	20 20	40 (10%)	40 (10%)
			16 (4%)	36 (9%)	77 (19%)	271 (68%)	400		



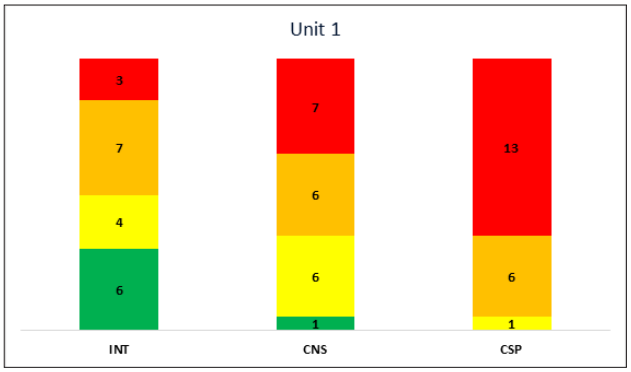
Graph 2 – RI-RADS Classification, for Conventional Radiology in Hospital Unit 1, with prescriptions broken down by origin (own source).



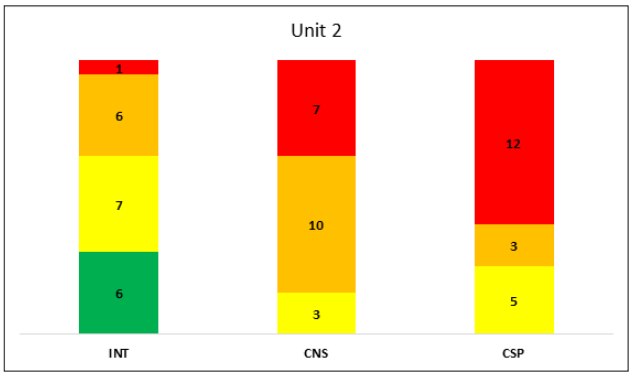
Graph 3 – RI-RADS Classification, for Conventional Radiology in Hospital Unit 2, with prescriptions broken down by origin (own source).



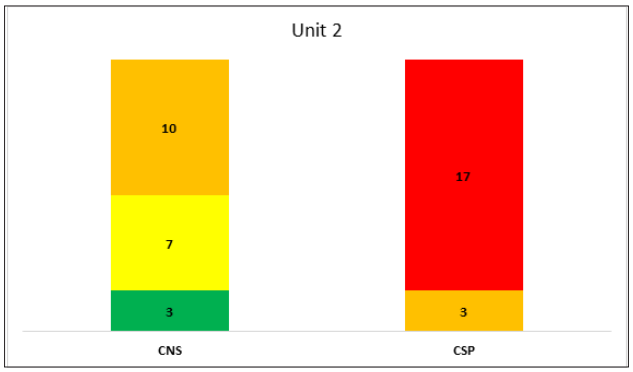
Graph 4 – RI-RADS Classification, for Conventional Radiology in Hospital Unit 3, with prescriptions broken down by origin (own source).



Graph 5 – RI-RADS Classification, for Computed Tomography, in Hospital Unit 1, with prescriptions broken down by origin (own source).



Graph 6 – RI-RADS Classification, for Computed Tomography in Hospital Unit 2, with prescriptions broken down by origin (own source).



Graph 7 – RI-RADS Classification, for Mammography, in Hospital Unit 2, with prescriptions broken down by origin (own source).

D. In primary care, only inadequate classifications were observed, with 85.0% RI-RADS D (n=17/20).
In the three radiological modalities evaluated, the RI-RADS D category was dominant (n=271/400).

Results by Prescription Origin
Regarding the origin of the prescriptions, the results highlighted differences in the quality of clinical information. The Emergency Department had the highest number of unfavourable classifications, with 96.7% (n=58/60) of exams classified as RI-RADS D, with no exams in categories A or B. Primary Care (PHC) continued to have a high proportion of RI-RADS D classifications (n=95/120; 79.2%).
Inpatient care recorded 57.0% (n=57/100) of RI-RADS D classifications, but had the highest percentage of RI-RADS A classifications (n=12/100), at 12.0%.
Inpatient care presented 50.8% of RI-RADS D classifications (n=61/120), and the highest percentage of RI-RADS B classifications, at 15.0% (n=18/120).

Discussion

Comparing Conventional Radiology, the only modality used across all hospital units, there is no evidence that the location of the prescription influences the RI-RADS classification assigned ($p=5.78$; $\alpha=0.05$).
On the other hand, there is statistically significant evidence that the origin of the request (emergency room, hospital consultation, inpatient, or primary care) influences the RI-RADS category assigned ($\chi2(9)=107.5$; $p<0.05$). The worst results are seen in the Emergency Department, which may be associated with greater work pressure or the fact that all prescribing physicians in this Department are external providers, without a permanent link to the institution, which may indicate a lower commitment to institutional values and standards. Primary Care follows, with the second-worst results, which may be explained by the physical distance from the Radiology Departments, which may hinder effective communication.
It was also found that the modality of the exam requested strongly influences the RI-RADS classification ($\chi2(6)=113.88$; $p<0.05$), being Conventional Radiology the modality with the worst results. This may be explained by the fact that the final evaluation of the exams is performed by the prescribing physician. The absence of a medical report from a radiologist may lead to less stringent clinical information requirements in the request.
Training and awareness-raising actions are important for all professionals involved in the justification process: prescribing physicians (both in Primary Care and Hospital Care), as well as those responsible for conducting the medical exposure.
It is recommended that the radiology exam request form be changed, with the single "clinical information" field divided into the three mandatory information categories recommended by the Portuguese College of Medicine (impression, clinical findings and diagnostic question).
It is also suggested that information regarding radiation doses associated with the exams be included in the prescription form11. This will increase awareness of the risks associated with ionizing radiation exposure and encourage accurate and effective detailed justification.
Despite the results obtained, this study has a limitation in that no physician integrated the audit team, which may influence the analysis of clinical information. In future audits, it would be relevant to consider including a prescribing physician and a radiologist, also involving the Quality Management Service.

Conclusion

In an era in which the IAEA (International Atomic Energy Agency) estimates that around 40% of radiological examinations are considered inappropriate 12, the correct justification of these examinations is extremely important to avoid unnecessary radiation exposure (in patients, accompanying people and professionals), inadequate and duplicate examinations, making the general provision of radiological medical care safer and more efficient 13.
In the LHU evaluated, most of the clinical information in radiological examination requests was inadequate (87%), being "inadequate" in 68% of cases and "considerably limited" in 19%, results in line with other similar studies 14. The worst results (RI-RADS C and D) were obtained in Conventional Radiology and in the Emergency Department, with the best results (RI-RADS A and B) found in CT and in inpatient care.
The implementation of clear and efficient protocols, combined with ongoing training and professional updating, will enable the promotion of increasingly sustainable, safe and effective care, aligned with the highest quality standards.
This study highlighted the need for improvements in the process of prescribing diagnostic exams using ionizing radiation and the urgent need for regular and ongoing evaluation of medical justifications.
What happens upstream is crucial to the quality of radiology reports and exams. The information provided in the request is crucial for assessing the suitability of the exam for the

right patient, at the right time, with a rigorous protocol, and using a precise structured report to obtain the most accurate conclusion, with the lowest radiation dose reasonably possible. By improving the quality of the input, we will surely achieve an effective improvement in the care provided to the patient, to whom we have our primary commitment.

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Ethical Disclosure / Divulgações Éticas

Conflicts of interest: The authors have no conflicts of interest to declare.

Conflitos de interesse: Os autores declaram não possuir conflitos de interesse.

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Confidentiality of data: The authors declare that they have followed the protocols of their work center on the publication of data from patients.

Confidencialidade dos dados: Os autores declaram ter seguido os protocolos do seu centro de trabalho acerca da publicação dos dados de doentes.

Protection of human and animal subjects: The authors declare that the procedures followed were in accordance with the regulations of the relevant clinical research ethics committee and with those of the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Protecção de pessoas e animais: Os autores declaram que os procedimentos seguidos estavam de acordo com os regulamentos estabelecidos pelos responsáveis da Comissão de Investigação Clínica e Ética e de acordo com a Declaração de Helsínquia da Associação Médica Mundial.

Authors' contribution statement: The methodology called "Contributor Roles Taxonomy" (CRedit) –https://credit.niso.org/

Rui Lopes: Conceptualization, Formal analysis, Research, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing of the original draft, Writing

Ana Reis: Conceptualization, Data Curation, Formal Analysis, Methodology, Resources, Software, Validation, Visualization, Writing

Declaração de contributo dos autores: Foi utilizada a metodologia denominada "Contributor Roles Taxonomy" (CRedit) –https://credit.niso.org/

Rui Lopes: Concetualização, Análise formal, Investigação, Metodologia, Administração do projeto, Recursos, Supervisão, Validação, Visualização, Redação do rascunho original, Redação

Ana Reis: Concetualização, Curadoria dos dados, Análise formal, Metodologia, Recursos, Software, Validação, Visualização, Redação

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