

Disability attribution in skin cancer: analysis of clinical decision-making profiles

Atribuição de incapacidade no cancro cutâneo: análise de perfis decisórios

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Abstract

Objectives: To analyze how dermatologists and dermatopathologists weigh different clinical criteria when attributing statutory disability certification for skin cancer at a disability threshold of $\geq 60\%$, a threshold associated with statutory benefits, and to identify underlying decision-making profiles. **Methods:** A cross-sectional observational study was conducted, based on a structured questionnaire administered to physicians practicing in Portugal. Criteria considered relevant for the issuance of a disability certificate and the 5-year survival threshold associated with clinical decision-making were assessed. Exploratory hierarchical cluster analysis was used to identify decision-making profiles, with evaluation of solution cohesion, stability, and separation. Associations between criteria, decision-making profiles, and tumor types were analyzed using appropriate association tests. The hierarchical structure of clinical decision-making was further explored using χ^2 automatic interaction detection (CHAID) analysis. **Results:** A total of 155 physicians responded. Two distinct decision-making profiles were identified: a predominant restrictive profile, primarily centered on criteria associated with advanced oncological disease, and a permissive profile, which consistently attributed greater relevance to complementary criteria, including tumor size or extent and anatomical location. This variability followed recognizable clinical patterns and was not associated with respondents' professional characteristics. The permissive profile adopted higher 5-year survival thresholds to justify disability certification. CHAID analysis confirmed the presence of a structured decision hierarchy, with morphological and anatomical criteria acting as initial discriminators. **Conclusion:** Despite a uniform legal framework, clinical decision-making in disability attribution for skin cancer shows substantial heterogeneity, organized into distinct decision-making profiles. These findings suggest that clearer hierarchical structuring of clinical criteria is feasible and may promote a more proportionate and equitable attribution of statutory disability benefits, better aligning social protection with clinically meaningful disability.

Keywords: Disability evaluation. Skin neoplasms. Clinical decision-making. Cluster analysis. Healthcare disparity.

Resumo

Objectivos: Analisar a forma como dermatologistas e dermatopatologistas ponderam diferentes critérios na decisão relativa à emissão de AMIM com grau de incapacidade $\geq 60\%$ no cancro cutâneo e identificar perfis decisórios subjacentes a essa prática. **Métodos:** Realizou-se um estudo observacional transversal, baseado num questionário estruturado aplicado a médicos a exercer em Portugal. Foram avaliados critérios considerados relevantes para a emissão de AMIM e o limiar de sobrevida

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Received: 09-07-2026

Accepted: 06-09-2026

DOI: 10.24875/PJDV.26000085

Available online: 26-10-2026

Port J Dermatol and Venereol. (ahead of print)

www.portuguesejournalofdermatology.com

a 5 anos associado à decisão clínica. Recorreu-se a análise exploratória de clusters hierárquicos para identificar perfis decisórios, com avaliação da coesão, estabilidade e separação da solução. As associações entre critérios, perfis decisórios e tipos de tumor foram analisadas por testes de associação apropriados. A estrutura hierárquica da decisão clínica foi explorada adicionalmente através de análise CHAID. **Resultados:** Responderam ao inquérito 155 médicos. Foram identificados dois perfis decisórios distintos: um perfil maioritário, mais restritivo, centrado em critérios associados à doença oncológica avançada, e um perfil permissivo, que valorizou de forma mais consistente critérios complementares, nomeadamente a dimensão/extensão tumoral e a localização anatómica. A variabilidade observada seguiu padrões clínicos reconhecíveis e não se associou a características profissionais dos respondentes. O perfil permissivo apresentou limiares de sobrevida a 5 anos mais elevados para justificar a emissão de AMIM. A análise CHAID confirmou a existência de uma hierarquia decisória estruturada, com critérios morfológicos e anatómicos a desempenhar um papel discriminativo inicial. **Conclusões:** Apesar de um enquadramento legal comum, a decisão clínica relativa à emissão de AMIM em oncologia cutânea revela heterogeneidade significativa, organizada em perfis decisórios distintos. Estes resultados sugerem que a clarificação e hierarquização dos critérios clínicos é possível e poderá permitir uma redistribuição mais justa e proporcional dos benefícios associados ao AMIM, reforçando a proteção social dos doentes com incapacidade clinicamente relevante.

Palavras chave: Incapacidade. Oncologia cutânea. Cancro. Atestado médico de incapacidade multiuso. Tomada de decisão clínica. Análise de clusters. Proporcionalidade clínica. Equidade em saúde.

Introduction

The assessment of the degree of disability in the oncological setting has historically been characterized by broad criteria and a substantial margin of clinical discretion. In Portugal, a key milestone was the creation of the multipurpose medical disability certificate (Atestado Médico de Incapacidade Multiuso, AMIM) by Decree-Law no. 174/97, establishing a single administrative instrument for the recognition of disability for social, economic, and fiscal purposes.¹ This framework aimed to standardize access to disability-related benefits, regardless of etiology, while delegating the clinical grading of disability to existing technical and regulatory instruments.

Medico-legal disability assessment relied on the National Table of Disabilities (Tabela Nacional de Incapacidades, TNI), initially approved by Decree-Law no. 341/93 and subsequently revised.^{2,3} The TNI was conceived as a guiding instrument, structured around broad clinical categories and wide percentage ranges, particularly in oncology. In its most recent formulation, it distinguished between stabilized chronic oncological disease (10-25% disability), malignant tumors without metastasis compatible with normal daily functioning (26-60% disability), and advanced malignant disease with poor prognosis (80-95% disability), without defining objective operational parameters for its application. This technical indeterminacy favored individualized assessment but left a substantial margin for interpretative variability in clinical practice.

Over time, however, successive legal and administrative reforms altered the balance between individual

clinical judgment and procedural standardization. In 2012, the mandatory requirement for a disability certificate to access exemptions from health care fees and various social, economic, and fiscal benefits led to a marked increase in requests for disability assessment, often at early stages of oncological disease.⁴ This contributed to the overload of medical boards and longer response times, a situation further exacerbated during the COVID-19 pandemic. In response, Law no. 14/2021 redistributed responsibility for certifying disability from medical boards to the clinical departments responsible for establishing the diagnosis.⁵

Within this evolving context, interpretative legal instruments were introduced. Informative Circular no. 6/2021 issued by the Central Administration of the Health System (ACSS) clarified that the attribution of a $\geq 60\%$ disability degree did not arise automatically from a new oncological diagnosis, but required explicit clinical justification and documentation.⁶ This position was subsequently reformulated. Law no. 1/2024 established a special procedure for oncological patients, determining the automatic attribution of a minimum disability degree of 60% for a period of 5 years.⁷ More recently, Ordinance no. 171/2025/1 consolidated this approach by allowing, in malignant tumors without metastases and compatible with normal daily functioning, the direct attribution of a 60% disability degree based exclusively on a medical and histopathological report.⁸

In Portugal, common malignancies, such as breast, prostate, and skin cancer, colorectal cancer, and non-muscle-invasive bladder tumors show high annual incidence and substantial cumulative lifetime incidence.^{9,10} Non-melanoma skin cancers, despite being

among the most frequent tumors in the population, are not included in national and international incidence estimates due to systematic underreporting in population-based cancer registries, limiting accurate quantification of their true burden. A significant proportion of these tumors are diagnosed at early stages and are associated with favorable prognosis and, in many cases, limited functional impact after treatment.¹⁰ In this context, the automatic attribution of high disability grades raises an ethical tension between necessary social protection and the requirement for clinical proportionality, particularly when applied to highly prevalent conditions with overall favorable clinical impact.

The succession of these legal instruments introduced tension – and increased uncertainty – between the normative framework and daily clinical practice, particularly in oncological dermatology, where prognostic, functional, and esthetic heterogeneity is pronounced, including a substantial proportion of cases with limited residual impact and favorable prognosis. Transferred responsibility for disability certification from medical boards to clinical departments altered the decision-making context and mechanisms for standardization. It remains uncertain whether dermatologists perceive these provisions as clinically appropriate or apply them uniformly.

Against this background, the present study aims to analyze how physicians evaluate different clinical and prognostic criteria of malignant skin tumors when deciding on disability certification with a 60% degree, providing an empirical basis to characterize decision-making patterns and frame the analytical approach that follows.

Methods

Study design

A cross-sectional observational study was conducted using a structured questionnaire administered to dermatovenereologists and dermatopathologists between 1 October 2025 and 11 January 2026. The study aimed to analyze how different clinical and prognostic criteria of malignant skin tumors are weighted in decision-making regarding disability certification.

Data collection instrument

The questionnaire was developed based on the current legal framework and routine clinical practice in oncological dermatology and implemented using the

Google Forms platform, allowing anonymous and voluntary data collection. The questionnaire was originally developed and administered in Portuguese; an English version is provided for transparency and reproducibility (Supplementary Material S1).

It included: (i) professional characteristics; (ii) self-reported familiarity with the legal framework; (iii) tumor-related clinical/prognostic criteria considered relevant to disability certification; and (iv) the minimum estimated 5-year survival threshold to justify issuance.

Open-ended questions addressing perceived difficulties and suggestions were included in the questionnaire but were not analyzed in the present study and are therefore not reported.

Responses related to clinical criteria were collected as dichotomous or ordinal variables, depending on question wording. All remaining variables were coded according to their measurement level (ordinal or continuous). Throughout the manuscript, the *certification of disability* by physicians refers to the issuance of the Portuguese multipurpose medical disability certificate, which entails the attribution of a disability degree of $\geq 60\%$.

Study population and data collection

The questionnaire was disseminated electronically through institutional and professional channels and targeted dermatologists and dermatopathologists practicing in Portugal. Participation was voluntary, unpaid, and anonymous. No personally identifiable data were collected.

Statistical analysis

Statistical analyses were performed using the IBM Statistical Package for the Social Sciences Statistics. Descriptive analysis used absolute/relative frequencies for categorical variables and measures of central tendency and dispersion for continuous variables.

To identify patterns of clinical decision-making, an exploratory cluster analysis was conducted based on responses to the evaluated clinical criteria. An unsupervised agglomerative hierarchical clustering approach was used, applying similarity measures appropriate for categorical variables. The number of clusters was defined through dendrogram inspection and assessment of clinical coherence. Cluster characterization was performed by comparing the distribution of variables across clusters.

Composite variables, such as tumor stage and overall prognosis, were not included in the clustering process, as they depend on combinations of other evaluated criteria.

Cluster cohesion, stability, and separation were assessed using complementary metrics. Internal cohesion was evaluated using intra-cluster inertia, calculated from the distance matrix as the sum of squared distances between all observation pairs within the same cluster, normalized by the number of possible pairs. Stability was assessed through random subsampling of 80% of the sample over 1,000 Monte Carlo iterations, using the adjusted Rand index (ARI) to quantify agreement between partitions. Cluster separation was evaluated using the silhouette coefficient, based on the normalized difference between mean intra-cluster distance and mean distance to the alternative cluster.

Associations between criteria considered relevant for disability certification, decision-making profiles, professional characteristics, and tumor type were analyzed using appropriate association tests for categorical variables. Pearson's χ^2 test was applied when assumptions were met; otherwise, Fisher's exact test or the Fisher-Freeman-Halton test was used, depending on contingency table size. The variable "minimum 5-year survival threshold to justify disability certification" (0-100%) was compared between clusters using the Mann-Whitney U test, given non-normal distribution. Statistical significance was set at $p < 0.05$.

The hierarchical structure of clinical decision-making was further explored using χ^2 Automatic Interaction Detection (CHAID) analysis, with the decision-making profile identified by cluster analysis as the dependent variable. This exploratory approach aimed to identify clinical criteria with the greatest discriminatory power and to characterize the hierarchical organization of decision-making. Bonferroni correction for multiple comparisons was applied, and minimum parent and child node sizes were defined to ensure robustness and interpretability.

Ethical considerations

Participation was voluntary and anonymous, and informed consent was implied by completion of the questionnaire. The study did not involve patients or identifiable clinical data and complied with ethical principles applicable to research involving healthcare professionals.

Results

Sample characterization

A total of 155 individuals responded to the survey, corresponding to a response rate of 31.8% from a total of 487 physicians contacted.¹¹ The median professional experience was 17.5 years (interquartile range [IQR] 10-26). Most participants worked across more than one setting (public and private); professional characteristics are summarized in Table 1.

Regarding Law no. 1/2024, the National Table of Disabilities (TNI), and ACSS Circular no. 6/2021, 49.7%, 71%, and 76% of participants, respectively, reported low familiarity with these instruments, while 40.5% of respondents reported having issued disability certificates on at least five occasions.

Criteria considered for disability certification

The most consensual criteria for disability certification were those associated with advanced oncological disease, namely, metastasis (98.8%), unresectable tumor (90%), complications related to treatment (88%) or to the tumor itself (81%), overall prognosis (79.5%), and the need for adjuvant or neoadjuvant therapy (78%).

Greater variability was observed in criteria related to disease stage, future impact on daily life, probability of metastasis, tumor recurrence, tumor size, location in anatomically "special areas", probability of recurrence, and esthetic sequelae of treatment. The distribution of responses for these criteria, hereafter referred to as complementary criteria, is presented in Figure 1.

When analyzed by tumor type, biologically aggressive malignancies, such as Merkel cell carcinoma and cutaneous sarcomas, were those for which 40% and 25% of respondents, respectively, reported willingness to certify disability in all cases. In contrast, 20% of respondents reported never considering certifying disability for basal cell carcinoma. For the remaining skin cancer types, between 74% and 95% of respondents reported considering the certification of disability in at least some cases.

Regarding high-risk histological features, 64/154 respondents considered certifying disability for basal cell carcinoma when aggressive subtypes were present (e.g., perineural and infiltrative/morpheaform patterns). In squamous cell carcinoma, 114/154 considered certifying

Table 1. Professional characteristics of the sample (n = 155)

Characteristic	n (%) or median (IQR)
Years of experience	17.5 (10-26)
Area of specialization*	
Medical dermatology	114 (73.5)
Surgical dermatology	98 (63.2)
Oncological dermatology	64 (41.3)
Dermatopathology	6 (3.9)
Work setting	
Public hospital	95 (61.3)
Private hospital	86 (55.5)
Clinic/private practice	91 (58.7)

*Responses were not mutually exclusive; participants could select more than one option.
IQR: interquartile range.

disability when poorer-prognosis features were present (including perineural invasion).

Identification of decision-making profiles through cluster analysis

Hierarchical cluster analysis focused on the complementary criteria, excluding consensual criteria, and identified two distinct decision-making profiles.

Cluster 0, comprising approximately two-thirds of respondents, was characterized by a more restrictive profile with lower weighting of complementary criteria. In contrast, Cluster 1 showed a more permissive profile, consistently attributing greater relevance to these criteria.

After normalization, mean intra-cluster inertia per pair was higher in the restrictive cluster (8.17) than in the permissive cluster (4.23), indicating greater internal dispersion in the former and greater decision alignment in the latter. Stability analysis demonstrated consistent agreement between partitions obtained through random subsampling (median ARI = 0.59; IQR 0.49-0.69). The mean silhouette coefficient was 0.40, indicating good separation between the two profiles despite individual variability.

Comparison between clusters revealed statistically significant differences in the weighting of complementary criteria for disability certification. The proportion of respondents within each cluster for each criterion is presented in Table 2. No statistically significant differences were observed between clusters regarding the previously identified consensual criteria.

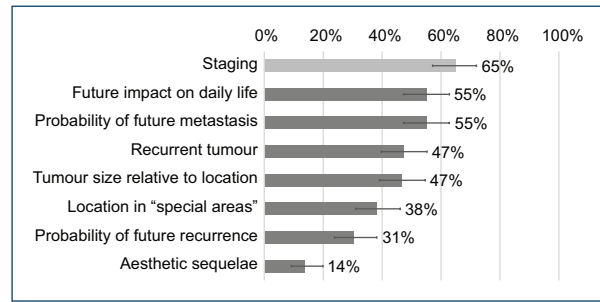


Figure 1. Complementary criteria considered relevant for the issuance of a disability certificate. Bars represent observed proportions; horizontal lines indicate 95% confidence intervals, estimated using the Wilson method.

Association between decision-making profiles and tumor types

Decision-making profiles showed tumor-specific associations. Consideration of disability certification in Merkel cell carcinoma and cutaneous sarcomas was predominantly associated with the restrictive profile. In contrast, certificate issuance for malignant melanoma, squamous cell carcinoma, malignant adnexal tumors, and dermatofibrosarcoma protuberans was predominantly associated with the permissive profile. No statistically significant associations were observed between decision-making profiles and basal cell carcinoma, atypical fibroxanthoma, Kaposi sarcoma, or primary cutaneous lymphomas.

Regarding the minimum 5-year survival threshold, the restrictive cluster showed a median threshold of 60% (IQR 50-75), whereas the permissive cluster showed a median threshold of 80% (IQR 50-90) (Fig. 2). This difference was statistically significant (Mann-Whitney U = 1585, Z = -3.005, p = 0.003, r = 0.25).

Relationship between decision-making profiles and respondent characteristics

No statistically significant associations were observed between cluster membership and years of clinical experience, workplace setting (public vs. private), or predominant area of differentiation.

CHAID analysis

CHAID analysis revealed a hierarchical organization of clinical decision-making. Initial splits were

Table 2. Complementary criteria considered for disability certification

Criterion	Cluster 0 (n = 104), n (%)	Cluster 1 (n = 50), n (%)	p*
Tumor size relative to location	22 (21.2)	50 (100)	< 0.001
Location in "special areas"	15 (14.4)	44 (88.0)	< 0.001
Future impact on daily life	42 (40.4)	43 (86.0)	< 0.001
Probability of metastasis	44 (42.3)	41 (82.0)	< 0.001
Recurrent tumor	34 (32.7)	39 (78.0)	< 0.001
Probability of future recurrence	16 (15.4)	31 (62.0)	< 0.001
Esthetic sequelae	18 (17.3)	3 (6.0)	0.056

*Differences between clusters were assessed using the χ^2 test or Fisher's exact test, as appropriate.

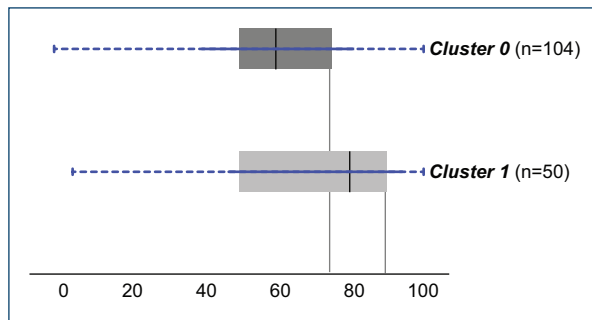


Figure 2. Boxplots of the 5-year survival threshold (%) below which respondents considered the issuance of a disability certificate to be justified, stratified by cluster. The permissive cluster showed a higher median, with substantial overlap between distributions, suggesting different implicit prognostic thresholds in clinical decision-making (Mann–Whitney U test, $p = 0.003$).

determined by tumor size or extent, followed by anatomical location, identifying these criteria as the main discriminatory axes between decision-making profiles (Fig. 3).

In more distal nodes, particularly within the permissive profile, additional criteria related to future impact on daily life, recurrence, and probability of metastasis emerged, albeit with reduced sample robustness.

Discussion

Despite a uniform legal framework for disability attribution ($\geq 60\%$) in skin cancer, dermatologists show substantial heterogeneity in how criteria are weighted to justify certifying disability.

The identification of two distinct decision-making profiles—a majority restrictive profile and a minority

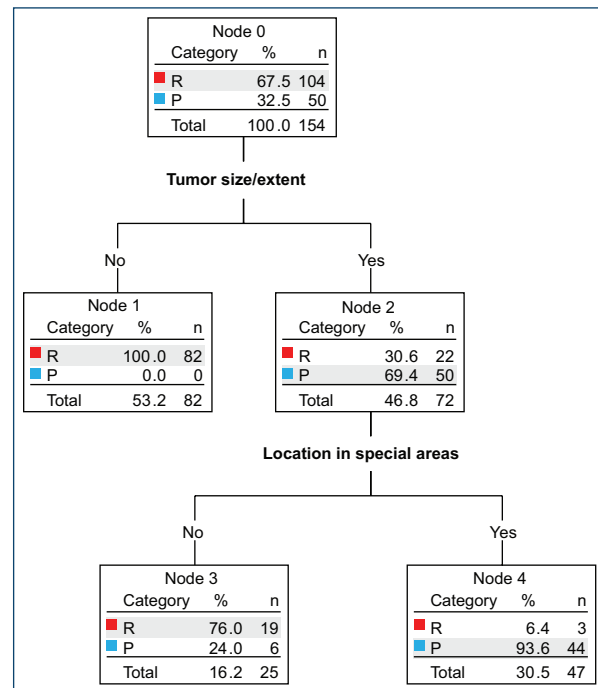


Figure 3. Hierarchical structure of clinical decision-making regarding certification of disability, obtained through X^2 automatic interaction detection analysis, with the decision-making profile identified by cluster analysis as the dependent variable (R: restrictive; P: permissive). The figure illustrates, for exploratory purposes, the clinical criteria with the greatest discriminatory power at the initial levels of decision-making. The splits at the initial levels of the tree were statistically significant after Bonferroni correction ($p < 0.001$).

permissive profile—indicates that clinical judgment is not uniformly applied within a shared legal framework. Importantly, this variability was not associated with

professional characteristics, such as years of experience, workplace setting, or area of differentiation, suggesting that it reflects underlying conceptual differences in how disease severity and its consequences are interpreted.

Analysis across tumor types further indicates that this variability follows recognizable clinical patterns rather than arbitrary reasoning. Rare and biologically aggressive tumors were associated with greater decisional convergence, whereas more common and clinically stratifiable tumors showed greater diversity in how severity and functional impact were interpreted. The weighting of high-risk histological features supports the presence of implicit decision thresholds, consistent with risk stratification models routinely applied in oncological practice.

Across multiple areas of oncology, clinical recommendations assist physicians in stratifying disease severity and guiding decisions with prognostic, therapeutic, and functional implications by integrating tumor type, stage, and risk of progression or recurrence.^{12,13} These approaches acknowledge that clinical severity is not a dichotomous concept but rather a gradual and multidimensional construct, dependent on functional impact and participation in daily life, and not solely on diagnosis or stage.^{12,14} It is therefore unsurprising that clinicians transpose hierarchical reasoning models into everyday practice.^{13,15} Similarly, disability should be understood as a multidimensional concept, dependent on the actual impact of disease and treatment on daily life, social participation, and residual functioning.^{14,15} In oncological dermatology, additional specificities – such as lesion visibility, stigma, and functional or esthetic sequelae – may have a disproportionate impact on quality of life, even in cases of lower biological severity.^{16–18}

The discrepancy between clinical judgment and the legal framework likely reflects the difficulty of translating the complex and individualized impact of oncological disease into general normative categories. In oncological dermatology, biological aggressiveness does not always correlate linearly with functional or psychosocial burden. Accordingly, a substantial proportion of respondents valued criteria extending beyond strictly biological parameters, particularly future impact on daily life, reflecting a patient-centered and quality-of-life-focused approach that remains insufficiently operationalized in current legislation.

The absence of differences between profiles regarding consensual criteria – such as metastatic or unresectable disease – suggests the existence of a shared

core of clinical understanding when biological severity is unequivocal. Divergence emerges primarily in intermediate scenarios, where prognosis is variable, and disability is driven predominantly by functional, esthetic, or quality-of-life impact. These situations appear particularly vulnerable to interpretative variability and may have direct implications for equity in access to the rights associated with disability certification.

Methodologically, the use of cluster analysis enabled the identification of latent decision-making patterns that would not be readily captured by conventional univariate approaches. The convergence of results across complementary analytical methods supports the internal consistency of the observed profiles and suggests that clinically informed disability attribution is structured hierarchically. Excluding consensual criteria, tumor size or extent and anatomical location emerged as initial organizing axes, followed by additional criteria related to functional impact and prognosis, indicating that the development of structured and standardized guidance is feasible.

Several limitations should be acknowledged. This study is based on a self-reported, scenario-based survey and may not fully reflect real-world clinical behavior. Although the response rate of 31.8% falls within the range commonly reported in voluntary physician surveys,¹⁹ selection bias cannot be excluded. Nevertheless, the consistency of the identified patterns across analytical approaches and the absence of associations with key professional variables strengthen the robustness of the findings.

Methodologically, although this study does not constitute a formal Delphi process, it shares with that approach the structured elicitation of expert judgment in contexts of normative uncertainty. Rather than seeking consensus, it empirically characterizes existing decision-making heterogeneity, providing a robust foundation for the future development of evidence-informed regulation, clinical guidance, or formal consensus initiatives. The proposed model could also be operationalized as an interactive digital decision-support tool, subject to prospective validation before any widespread clinical implementation.

Overall, the results reveal a clear structural divergence between clinical reasoning and the normative interpretation of disability in skin cancer. Recognizing this heterogeneity is essential to clarify applicable criteria, promote greater consistency and proportionality in clinical practice, and support a fairer redistribution of benefits associated with disability certification, thereby

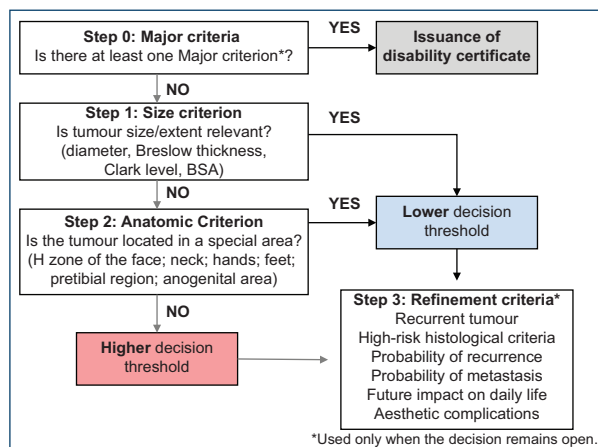


Figure 4. Conceptual synthesis of clinical decision-making patterns related to issuance of a medical disability certificate. The diagram illustrates a hierarchical organization of the clinical criteria identified in the study, distinguishing consensual (“Major”) criteria from complementary criteria that modulate the clinical decision threshold. The consensual (“Major”) criteria, described in the text, include metastasis, unresectable tumor, complications or sequelae with organic or functional impact resulting from the tumor or its treatment, and the need for adjuvant or neoadjuvant therapy. Complementary criteria include parameters, such as Breslow thickness (tumor thickness in millimeters) and Clark level (anatomical level of invasion); H zone (high-risk anatomical areas of the face); BSA (body surface area affected); high-risk histological features (see text); esthetic impact; and future impact on daily life. This representation is conceptual and illustrative in nature and does not constitute a normative proposal or a validated clinical algorithm.

strengthening social protection for patients with clinically meaningful disability.

Conclusion

This study shows that, despite a uniform legal framework, the issuance of a disability certificate in the context of skin cancer is characterized by substantial clinical heterogeneity, with the identification of distinct decision-making profiles among dermatologists. This variability emerges primarily in intermediate clinical scenarios, in which biological severity is not unequivocal and functional, esthetic, or quality-of-life impact plays a decisive role.

The results further indicate that decision-making profiles vary according to tumor type, reflecting an implicit distinction between rare, biologically aggressive

malignancies and more frequent, clinically stratifiable tumors, in which functional impact tends to carry greater weight.

The absence of an association between decision-making profiles and respondents’ professional characteristics suggests that the observed differences reflect distinct conceptual models of disability assessment rather than factors related to experience, training, or practice setting. This finding raises important questions regarding equity and consistency in the application of criteria underlying disability attribution, particularly in the context of a legal framework that allows for automatic or simplified certification.

Based on these findings, we propose the conceptualization of a structured clinical decision tree integrating biological, prognostic, and functional criteria in a transparent and hierarchical manner (Fig. 4). Such a model could support both the initial issuance and renewal of a disability certificate, reduce inter-clinician variability, and improve alignment between normative provisions and individualized medical assessment. An additional potential advantage is a more appropriate and proportionate valuation of the social and fiscal benefits associated with the certification of disability in the oncological setting.

Overall, the future development and validation of structured, clinically grounded decision frameworks may represent an important step toward a more consistent, proportionate, and patient-centered attribution of disability, with potential applicability extending beyond oncological dermatology.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest

The authors declare no conflicts of interest relevant to this work.

Ethical considerations

Protection of human subjects and animals. The authors declare that no experiments on humans or animals were performed for this research.

Confidentiality, informed consent, and ethical approval. This study does not involve personal patient data, medical records, or biological samples, and does

not require ethical approval. SAGER guidelines do not apply.

Declaration on the use of artificial intelligence (AI). The authors declare that ChatGPT (OpenAI) was used solely for language editing and stylistic refinement. All scientific content, analyses, interpretations, and conclusions were developed and approved by the authors.

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