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PEDIATRIC HEADACHE: A DIAGNOSTIC APPROACH BASED ON RED FLAGS

CEFALEIA PEDIÁTRICA: UMA ABORDAGEM DIAGNÓSTICA BASEADA EM SINAIS DE ALERTA

CEFALEA PEDIÁTRICA: UN ENFOQUE DIAGNÓSTICO BASADO EN SIGNOS DE ALARMA

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Resumo
A cefaleia é uma das queixas neurológicas mais frequentes em crianças e adolescentes, representando um motivo comum de consulta médica. Embora a maioria dos casos corresponda a cefaleias primárias, uma parcela pode estar associada a condições subjacentes graves que exigem diagnóstico precoce. A diferenciação entre cefaleias primárias e secundárias permanece um dos principais desafios na prática clínica pediátrica. Este estudo tem como objetivo apresentar uma abordagem diagnóstica estruturada e baseada em evidências para a cefaleia pediátrica, com ênfase na identificação e interpretação dos sinais de alerta e no uso adequado da neuroimagem. Foi realizada uma revisão narrativa da literatura, incluindo estudos publicados entre 2010 e 2024 em bases de dados relevantes. Sinais de alerta como exame neurológico anormal, padrão progressivo da dor, vômitos persistentes, crises epilépticas e sinais de hipertensão intracraniana estão fortemente associados a causas secundárias. No entanto, seu valor preditivo é variável, e achados isolados frequentemente apresentam baixa especificidade. Evidências indicam que a combinação de múltiplas variáveis clínicas aumenta a acurácia diagnóstica. A neuroimagem não deve ser realizada rotineiramente em crianças com cefaleia recorrente e exame neurológico normal, sendo a ressonância magnética o método de escolha quando indicada. Uma abordagem sistemática e probabilística — que integre história clínica, exame neurológico, interpretação contextual dos sinais de alerta e uso criterioso da neuroimagem — permite otimizar a precisão diagnóstica e reduzir intervenções desnecessárias, garantindo maior segurança ao paciente e melhor utilização dos recursos em saúde.
Palavras-chave: Cefaleia pediátrica; Sinais de alerta; Neuroimagem; Cefaleia secundária; Enxaqueca

Abstract

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Headache is one of the most common neurological complaints in children and adolescents, representing a frequent reason for medical consultation. Although most cases correspond to primary headache disorders, a minority may be associated with serious underlying conditions requiring prompt diagnosis. Distinguishing between primary and secondary headache remains a major challenge in pediatric clinical practice. This study aims to present a structured and evidence-based diagnostic approach to pediatric headache, emphasizing the identification and interpretation of red flags and the appropriate use of neuroimaging. A narrative review of the literature was conducted, including studies published between 2010 and 2024 in major databases. Red flags such as abnormal neurological examination, progressive headache pattern, persistent vomiting, seizures, and signs of intracranial hypertension are strongly associated with secondary causes. However, their predictive value varies, and isolated findings often lack specificity. Evidence suggests that combining multiple clinical variables improves diagnostic accuracy. Neuroimaging should not be routinely performed in children with recurrent headache and normal neurological examination, with magnetic resonance imaging being the preferred modality when indicated. A systematic and probabilistic approach—integrating clinical history, neurological examination, contextual interpretation of red flags, and judicious use of imaging—allows clinicians to optimize diagnostic accuracy while minimizing unnecessary interventions. This approach is essential to ensure patient safety and efficient use of healthcare resources.
Keywords: Pediatric headache; Red flags; Neuroimaging; Secondary headache; Migraine

Resumen
La cefalea es una de las quejas neurológicas más frecuentes en niños y adolescentes, constituyendo un motivo común de consulta médica. Aunque la mayoría de los casos corresponden a cefaleas primarias, una minoría puede estar asociada a condiciones subyacentes graves que requieren diagnóstico oportuno. Diferenciar entre cefaleas primarias y secundarias sigue siendo un desafío importante en la práctica clínica pediátrica. Este estudio tiene como objetivo presentar un enfoque diagnóstico estructurado y basado en evidencia para la cefalea pediátrica, enfatizando la identificación e interpretación de los signos de alarma y el uso adecuado de la neuroimagen. Se realizó una revisión narrativa de la literatura, incluyendo estudios publicados entre 2010 y 2024 en bases de datos relevantes. Los signos de alarma como el examen neurológico anormal, patrón progresivo de la cefalea, vómitos persistentes, convulsiones y signos de hipertensión intracraneal se asocian fuertemente con causas secundarias. Sin embargo, su valor predictivo varía y los hallazgos aislados suelen tener baja especificidad. La evidencia sugiere que la combinación de múltiples variables clínicas mejora la precisión diagnóstica. La neuroimagen no debe realizarse de forma rutinaria en niños con cefalea recurrente y examen neurológico normal, siendo la resonancia magnética el método preferido cuando está indicada. Un enfoque sistemático y probabilístico—que integre historia clínica, examen neurológico, interpretación contextual de los signos de alarma y uso racional de la

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neuroimagen—permite optimizar la precisión diagnóstica y reducir intervenciones innecesarias.
Palabras clave: Cefalea pediátrica; Signos de alarma; Neuroimagen; Cefalea secundaria; Migraña

1. Introduction

Headache is one of the most prevalent neurological symptoms in children and adolescents, with epidemiological studies indicating that up to 80–90% of individuals will experience at least one episode before reaching adulthood, and approximately 10–20% may develop recurrent or chronic headache disorders. Although the majority of cases are attributed to primary headache disorders—particularly migraine and tension-type headache—secondary headaches, though less frequent, may reflect serious and potentially life-threatening conditions, including intracranial neoplasms, central nervous system infections, vascular abnormalities, hydrocephalus, and disorders associated with increased intracranial pressure.

The developing brain presents unique physiological and anatomical characteristics that may influence both the clinical expression and the underlying mechanisms of headache in pediatric populations. Age-related differences in symptom description, pain perception, and neurological maturation often make the diagnostic process more challenging when compared to adults. Additionally, younger children may have limited ability to accurately characterize headache features, which further complicates clinical assessment and increases reliance on caregiver reports and objective findings.

In clinical practice, one of the most critical challenges is the accurate differentiation between primary and secondary headaches. While excessive investigation may lead to unnecessary exposure to sedation, radiation (in the case of computed tomography), increased healthcare costs, and parental anxiety, insufficient evaluation may result in delayed diagnosis of serious conditions with potentially severe outcomes. Therefore, clinicians must adopt a balanced and

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evidence-based approach that maximizes diagnostic accuracy while minimizing harm.

Within this context, the concept of “red flags” has become a cornerstone in the evaluation of pediatric headache. Red flags are clinical features derived from patient history and physical or neurological examination that suggest an increased likelihood of secondary causes. Traditionally described warning signs include early morning vomiting, progressive worsening of headache, nocturnal awakening, focal neurological deficits, seizures, and papilledema. However, emerging evidence indicates that the predictive value of individual red flags varies significantly. Some commonly cited features, such as occipital headache or isolated nocturnal pain, may occur in benign primary headache disorders and should not be interpreted in isolation. Conversely, the presence of abnormal neurological findings or signs of raised intracranial pressure remains strongly associated with clinically significant intracranial pathology.

Recent studies have emphasized the importance of combining multiple clinical variables rather than relying on isolated warning signs, promoting a more nuanced and probabilistic approach to diagnosis. In this regard, structured clinical assessment tools and decision-making algorithms have been proposed to improve diagnostic accuracy and guide the appropriate use of complementary investigations, particularly neuroimaging.

Neuroimaging plays a central role in the evaluation of suspected secondary headache; however, current guidelines consistently recommend against its routine use in children with recurrent headache and a normal neurological examination. The diagnostic yield of neuroimaging in such cases is low, and incidental findings may lead to further unnecessary investigations and anxiety. Magnetic resonance imaging (MRI) is generally preferred over computed tomography (CT) due to its superior sensitivity and lack of ionizing radiation, especially in the pediatric population.

Given these considerations, there is a clear need for a structured, clinically oriented, and evidence-based approach to pediatric headache evaluation that

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integrates detailed history-taking, thorough neurological examination, and judicious use of diagnostic tools.

Therefore, this article aims to provide a comprehensive and practical framework for clinicians, focusing on:

1. Differentiation between primary and secondary headaches;
2. Identification and interpretation of clinically relevant red flags;
3. Evidence-based indications for neuroimaging.

By aligning clinical reasoning with the most recent literature, this review seeks to enhance diagnostic accuracy, optimize resource utilization, and improve patient safety in the management of pediatric headache.

2. Methodology

This study consists of a narrative review conducted to synthesize current evidence on the diagnostic approach to pediatric headache, with emphasis on red flags and neuroimaging indications.

A literature search was performed in the following databases: PubMed/MEDLINE, Scopus, and Web of Science. The search strategy included combinations of the terms: *"pediatric headache"*, *"red flags"*, *"secondary headache"*, *"neuroimaging"*, and *"diagnostic approach"*.

Articles published between 2010 and 2024 were prioritized, with inclusion of seminal references when relevant. Inclusion criteria comprised clinical studies, systematic reviews, guidelines, and consensus statements focusing on pediatric populations. Exclusion criteria included studies restricted to adult populations or lacking clinical applicability.

Given the narrative nature of the review, no formal systematic protocol (e.g., PRISMA) was applied. However, efforts were made to include high-quality and clinically relevant sources.

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Potential limitations include selection bias and heterogeneity among included studies, particularly regarding definitions and predictive value of red flags.

Table 1. Main Differences Between Primary and Secondary Headaches in Children

Feature	Primary Headache	Secondary Headache
Onset	Gradual	Sudden or progressive worsening
Neurological exam	Normal	May be abnormal
Associated symptoms	Photophobia, phonophobia, náusea	Vomiting, focal deficits, altered consciousness
Course	Recurrent, stable pattern	Progressive or atypical
Response to treatment	Usually good	Often poor

Beyond these classical distinctions, clinicians should be aware of overlapping features. For example, vomiting and severe pain intensity may occur in migraine, potentially mimicking secondary causes. Conversely, early stages of intracranial pathology may present with nonspecific symptoms resembling primary headache. Therefore, the diagnostic process should not rely solely on isolated features but rather on a comprehensive integration of clinical history, physical examination, and evolution over time.

Importantly, epidemiological data indicate that while secondary headaches represent a small proportion of cases in outpatient settings, their prevalence increases in emergency contexts, where up to 10–20% of children presenting with acute headache may have an identifiable secondary cause. This highlights the importance of clinical context in diagnostic reasoning.

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In summary, although primary headaches—particularly migraine—are the most common etiology in pediatric patients, the clinician's primary responsibility is to identify those cases suggestive of secondary pathology, ensuring timely investigation and management. A structured approach that integrates clinical patterns, neurological findings, and red flags is essential to achieve accurate diagnosis and optimize patient outcomes.

Recent evidence suggests that the diagnostic performance of red flags is highly variable. Studies have demonstrated that while abnormal neurological examination may present sensitivity rates above 80% for detecting intracranial pathology, many isolated red flags—such as nocturnal headache or occipital pain—have low specificity and may frequently occur in benign conditions.

For instance, Conti et al. (2023) reported that the presence of at least one red flag is common in children with primary headache, reducing its positive predictive value when used in isolation. Conversely, the combination of multiple red flags significantly increases diagnostic accuracy, supporting a probabilistic rather than dichotomous approach.

Therefore, the indiscriminate use of red flags as absolute indicators for neuroimaging may lead to over-investigation, unnecessary costs, and increased parental anxiety.

4. Red Flags in Pediatric Headache

Red flags are clinical features identified through history and physical or neurological examination that increase the likelihood of secondary headache and should prompt further diagnostic evaluation. In pediatric populations, the recognition of these warning signs is particularly critical, as early identification of serious underlying conditions may significantly impact prognosis and clinical outcomes.

The concept of red flags has been widely incorporated into clinical practice; however, recent studies emphasize that their diagnostic value is not uniform. Instead, the predictive accuracy of red flags depends on their combination,

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persistence, and association with abnormal findings on examination. Therefore, clinicians should adopt a contextual and integrative approach, rather than relying on isolated symptoms.

Key Red Flags:

- Persistent or progressively worsening headache;
- Early morning headache or recurrent vomiting, particularly upon awakening;
- Headache that awakens the child from sleep;
- Abnormal neurological examination (e.g., focal deficits, ataxia, altered consciousness);
- Papilledema or other signs of increased intracranial pressure;
- Seizures associated with headache;
- Personality, cognitive, or behavioral changes;
- Age < 5 years at onset;
- Occipital headache (interpretation dependent on clinical context).

Among these features, abnormal neurological findings remain the most robust predictor of secondary intracranial pathology. The presence of focal deficits, cranial nerve abnormalities, or altered mental status significantly increases the likelihood of structural lesions, including tumors or vascular abnormalities.

Similarly, persistent or recurrent vomiting, especially when associated with early morning headache, is strongly suggestive of increased intracranial pressure. This pattern is classically described in intracranial tumors and hydrocephalus, although it may occasionally overlap with migraine presentations in children.

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Papilledema represents a critical red flag, indicating raised intracranial pressure and warranting urgent neuroimaging. However, its absence does not exclude intracranial pathology, particularly in early stages.

Seizures occurring in association with headache should also raise concern for underlying structural or inflammatory conditions, particularly when they are new-onset or focal in nature. Additionally, behavioral or personality changes, such as irritability, cognitive decline, or school performance deterioration, may reflect frontal or diffuse cerebral involvement and should not be underestimated.

Age at presentation is another important consideration. Headache in children younger than 5 years is less common and more likely to be secondary, partly due to developmental limitations in symptom reporting and higher prevalence of structural etiologies in this age group.

Importantly, not all traditionally described red flags have high specificity. For instance, nocturnal awakening and occipital headache, historically considered alarming, have been shown in recent studies to occur in benign primary headache disorders, particularly migraine. Therefore, these features should not automatically trigger neuroimaging in the absence of additional concerning findings.

Recent evidence supports the use of combined clinical predictors rather than isolated red flags to improve diagnostic accuracy. Clinical decision-making models integrating multiple variables—such as abnormal neurological examination, progressive course, and systemic symptoms—demonstrate higher sensitivity and specificity for identifying secondary causes.

In summary, the evaluation of red flags in pediatric headache should be systematic, contextual, and evidence-based. While certain findings—particularly abnormal neurological examination and signs of increased intracranial pressure—strongly indicate the need for further investigation, others require careful interpretation within the broader clinical picture. This nuanced approach helps avoid both overuse of neuroimaging and missed diagnoses of serious conditions, ultimately improving patient safety and quality of care.

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5. Indications for Neuroimaging

Neuroimaging plays a crucial role in the evaluation of pediatric headache when there is suspicion of secondary causes. However, current evidence and international guidelines consistently emphasize that neuroimaging should not be routinely performed in children presenting with recurrent headache and a normal neurological examination, as the diagnostic yield in such cases is low.

Unnecessary imaging may expose children to potential risks, including sedation (particularly in younger patients undergoing MRI), radiation exposure in the case of computed tomography (CT), incidental findings leading to further investigations, and increased healthcare costs. Therefore, the decision to perform neuroimaging must be guided by clinical judgment supported by well-established indications.

The presence of red flags, particularly when multiple are presente, should prompt consideration of imaging. Among these, abnormal neurological examination findings and signs of increased intracranial pressure are the most reliable predictors of significant intracranial pathology.

Magnetic resonance imaging (MRI) is the preferred modality in most cases due to its superior sensitivity for detecting parenchymal, posterior fossa, and vascular abnormalities, as well as its advantage of avoiding ionizing radiation. CT, although faster and more accessible, should generally be reserved for emergency situations, such as suspected acute hemorrhage or trauma.

International recommendations are largely consistent but present subtle differences. The American College of Radiology (ACR) emphasizes imaging primarily in the presence of abnormal neurological findings or strong clinical suspicion of secondary causes. In contrast, some European guidelines adopt a slightly broader approach, considering imaging in selected cases with atypical clinical evolution even in the absence of clear neurological deficits.

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Despite these differences, there is consensus that routine neuroimaging is not indicated in children with recurrent headache and normal neurological examination.

Table 2. Indications for Neuroimaging in Pediatric Headache

Clinical Feature	Description	Suggested Action
Abnormal neurological examination	Focal deficits, cranial nerve abnormalities, ataxia, altered consciousness	Urgent MRI
Signs of increased intracranial pressure	Papilledema, persistent vomiting, headache worse in the morning	Urgent MRI ± ophthalmologic evaluation
Recent onset of severe headache	Sudden or “first worst” headache	Consider urgent imaging (MRI or CT depending on context)
Progressive worsening pattern	Increasing frequency, intensity, or change in headache pattern	MRI indicated
Seizures associated with headache	New-onset seizures, especially focal	MRI indicated
Systemic symptoms	Fever, weight loss, immunosuppression, malignancy history	MRI with contrast
Age < 5 years with new headache	Limited symptom description; higher risk of secondary causes	Low threshold for Imaging
Headache with behavioral or cognitive changes	Personality changes, school decline, lethargy	MRI indicated

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It is important to highlight that isolated headache without additional concerning features rarely justifies neuroimaging, particularly in cases with a typical migraine pattern and normal neurological examination. Studies have demonstrated that the prevalence of clinically significant findings in such patients is extremely low, often below 1–2%.

Conversely, the presence of multiple risk factors significantly increases the probability of detecting intracranial pathology. Clinical decision-making should therefore rely on risk stratification, combining history, examination, and red flag assessment.

Another relevant consideration is the increasing recognition of incidental findings in neuroimaging studies, such as benign cysts or nonspecific white matter changes, which may lead to unnecessary anxiety and additional testing. This further reinforces the importance of judicious imaging use.

From a practical standpoint, MRI protocols in pediatric headache evaluation should ideally include sequences sensitive to tumors, vascular abnormalities, and intracranial pressure changes. The use of contrast should be guided by clinical suspicion, particularly in cases of infection, inflammation, or neoplasia.

6. Practical Clinical Approach

The evaluation of headache in children requires a systematic, structured, and patient-centered approach, integrating clinical history, physical examination, and selective use of complementary investigations. Such an approach is essential to accurately differentiate primary from secondary headaches while minimizing unnecessary interventions.

A detailed clinical history remains the cornerstone of diagnosis. Key elements include onset, duration, frequency, location, intensity, and quality of pain, as well as associated symptoms such as nausea, vomiting, photophobia, phonophobia, and

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aura phenomena. Particular attention should be given to the temporal pattern (acute, recurrent, chronic-progressive) and the presence of triggering or relieving factors. Family history of migraine or other primary headache disorders is also highly relevant, given the strong genetic predisposition observed in pediatric populations.

The neurological examination is equally critical and should be comprehensive, including assessment of mental status, cranial nerves, motor and sensory function, coordination, gait, and fundoscopy. The identification of abnormal findings—especially focal neurological deficits or signs of increased intracranial pressure—represents a key determinant in the decision to pursue further investigation.

Following history and examination, clinicians should proceed with the identification and interpretation of red flags, recognizing that their predictive value is maximized when considered collectively rather than in isolation. The integration of multiple clinical warning signs significantly improves diagnostic accuracy and helps stratify patients according to risk.

The judicious use of neuroimaging is a fundamental component of this approach. Imaging should be reserved for patients with clinical features suggestive of secondary headache, particularly those with abnormal neurological examination, progressive symptomatology, or signs of intracranial hypertension. In contrast, children with recurrent headaches consistent with migraine and a normal examination generally do not require imaging.

Stepwise Clinical Approach to Pediatric Headache

Step	Clinical Action	Key Objective
	Detailed clinical history	Identify headache pattern and associated features

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Step	Clinical Action	Key Objective
	Complete neurological examination	Detect focal deficits or signs of increased intracranial pressure
	Red flag assessment	Stratify risk of secondary headache
	Decision on neuroimaging	Apply evidence-based indications
	Clinical follow-up	Monitor evolution and reassess if needed

An important aspect of management is the recognition that headache diagnosis is often dynamic, requiring longitudinal assessment. Children initially diagnosed with primary headache should be periodically reassessed, particularly if there is a change in pattern, frequency, or severity.

Additionally, clinicians should consider the broader psychosocial context, including school performance, sleep patterns, screen exposure, and emotional factors, all of which may influence headache frequency and severity. A biopsychosocial approach is therefore essential in comprehensive pediatric care.

7. Limitations

This review has inherent limitations due to its narrative design. The absence of a systematic methodology may introduce selection bias, and the heterogeneity of included studies limits direct comparison of diagnostic performance metrics.

Additionally, variability in the definition and interpretation of red flags across studies may affect the generalizability of findings.

Future research should focus on prospective validation of clinical decision models integrating multiple predictors.

8. Conclusion

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Headache in children represents a diagnostic challenge that requires balancing clinical vigilance with the avoidance of unnecessary investigations.

Although red flags remain a central component of evaluation, their interpretation should not be absolute. The available evidence suggests that isolated warning signs have limited predictive value, whereas combined clinical assessment significantly improves diagnostic accuracy.

A structured and probabilistic approach—integrating clinical history, neurological examination, and contextual interpretation of red flags—provides a safer and more efficient diagnostic strategy.

Ultimately, advancing pediatric headache care depends not only on adherence to guidelines but also on critical clinical reasoning and individualized patient assessment.

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