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An Educational Intervention Regarding Headache Management to Increase the Knowledge of Emergency Department Providers in a Tertiary Care Facility – A Quality Improvement Project

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Abstract

Background: Effective headache management in emergency departments (EDs) is critical for patient outcomes. However, there is often a knowledge gap among providers regarding best practices. This study evaluates the impact of an educational intervention aimed at enhancing ED providers' knowledge and practices in headache management.

Methods: A quality improvement (QI) project was implemented involving pre- and post-intervention assessments. The educational intervention included a voice-over PowerPoint on headache management.

Results: The increase in mean score from 13.71 to 17.00 indicates that the intervention effectively enhanced providers' understanding of headache management. Additionally, the decrease in standard deviation from 2.74 to 1.53 reflects a more uniform level of knowledge post-intervention, suggesting that the educational content was well-received and comprehended similarly by the participants. Wilcoxon signed-rank test results suggest that the educational intervention had a positive impact on the participants' knowledge levels regarding headache management. The results indicate a notable improvement in knowledge scores following the educational intervention.

Conclusion: The educational intervention significantly enhanced the knowledge of ED providers concerning headache management. These findings support the implementation of regular training programs to improve provider competence and patient care outcomes in emergency settings.

Keywords: headache, medication overuse headache, neuroimaging, magnetic resonance imaging brain, magnetic resonance angiography brain, magnetic resonance venography brain, computed tomography brain, computed tomography angiography brain, computed tomography venography brain, knowledge gap

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Introduction

Headache is one of the most prevalent and disabling conditions in the United States (US). Overall, the estimated global prevalence of headache disorders in high-income countries is approximately 52% (Stovner et al., 2022). Headache may occur as a primary disorder or be secondary to another condition. Some causes of headache are common; however, others like subarachnoid hemorrhage, meningitis, and encephalitis, are important to recognize because they are life-threatening and require specific diagnostic testing and treatment (Stovner et al., 2022). Unfortunately, headache is a pathology that is usually belittled, underdiagnosed, and often undertreated (Miller & Matharu, 2014). This has had a negative impact on the quality-of-care patients receive.

Problem Statement

Headaches are one of the most frequent reasons why patients seek care at the ED. The chief complaint of headache can pose a great challenge to ED providers, as the distinction between a primary headache and a secondary headache can be difficult (Stovner et al., 2022). The World Health Organization (WHO) published a report describing the burden due to headache disorders and resources available to reduce them (Steiner et al., 2021). Worldwide, healthcare providers receive an average of four hours of training related to headache disorders (Steiner et al., 2021). Lack of knowledge among healthcare providers is the principal barrier to quality care. Diagnostic testing and treatment modalities vary based on the individual clinician who evaluates the patient. Providers in the ED are very busy and usually have a very limited time to determine which patients require further diagnostic evaluation as well as determine the optimal medication to use for headache relief.

Consequences of the Problem

As alluded to earlier, inappropriate diagnosis and management of headaches in the ED can lead to poor clinical outcomes. Overwhelmingly, research suggests a high rate of misdiagnosis of headache disorders in the ED. Most patients who go to the ED complaining of a headache receive the same treatment plan regardless of the cause of the headache. Many times, at the time of discharge patients still have a headache. Without proper evaluation, healthcare providers may misdiagnose the underlying cause of the headache, leading to inappropriate treatment or missed serious conditions. To highlight this fact, the routine use of computerized tomography (CT) scan for non-traumatic headache in the United States EDs has doubled in the last 20 years; however, approximately 95% of the CT scans show no pathological findings (Negro et al., 2020).

The inadequate acute treatment of headache disorders can also potentially worsen the condition. Ineffective management leads to delays in providing treatment. Delayed treatment leads to the chronification of the headache disorder. Poor headache management can result in persistent pain, disability, and a considerably reduced quality of life (Ziegeler et al., 2019).

Inexperienced clinicians managing headache may also lead to the excessive use of medications, potentially causing side effects and medication overuse headaches (MOH) (Ziegeler et al., 2019). ED providers frequently prescribe a combination medication that contains butalbital, acetaminophen, and caffeine. This medication among other similar combinations has serious side effects, including an increased risk of rebound headaches and MOH. There are far more effective and safer options for the treatment of headache.

Lastly, there are the ethical and legal implications of the improper management of headache. Inappropriate management of headache may have important legal ramifications. There

are several legal cases reporting that monetary damages were paid because of gross negligence associated with the under treatment of pain causing undue suffering (Jukić & Puljak, 2018). Pain relief is also a core ethical duty in healthcare. Healthcare providers are required to uphold ethical standards, such as beneficence and non-maleficence, which prohibits the infliction of harm to patients. Failure to reasonably treat pain and suffering, could theoretically be considered an ethical breach of conduct (Jukić & Puljak, 2018).

Knowledge Gap

There are several areas where information about headache management in ED may be lacking or incomplete. While there are guidelines for the management of various types of headache disorders, including migraine and tension headache, there is a lack of universally accepted, evidenced-based guidelines, specifically tailored to the emergency setting (Giamberardino et al., 2020). This can lead to a considerable variability in the approach to headache in the ED and may result in suboptimal care. Depending on where ED providers trained, some may have not received much formal education in headache management, which makes it imperative to address this issue.

Proposal Solution

A clear and standardized approach to headache management in the ED is of paramount importance. Differentiating primary headaches from secondary headaches can be difficult. This project seeks to improve the current practice at a tertiary care facility by avoiding unnecessary diagnostic testing in accordance with established guidelines. The writer plans to provide an educational resource to review appropriate use of imaging exams. The goal is to improve clinician knowledge; thus, changing their practice habits. Ultimately, the expectation is that this project will improve consistency in care and improve patient outcomes. Providing clinicians with

appropriate information and resources on how to approach headache is essential to providing quality care to patients. Developing an educational training program, in collaboration with a headache specialist, will hopefully improve headache management in the ED setting. It is anticipated that this project will have a significant impact in improving care delivery, reducing unnecessary diagnostic testing, reducing hospital length of stay, and improving patient outcomes.

This literature review underscores the importance of ongoing research and standardized education initiatives to enhance headache management in the ED and ultimately improve patient care.

Summary of the Literature

Primary Headaches

Primary headaches are a category of headaches that occur independently and are not caused by an underlying medical condition or external factors. These headaches are characterized by pain or discomfort in the head or neck region and can be recurrent. Below this writer will provide an overview of primary headaches including migraines, tension-type headache, cluster, Trigeminal Autonomic Cephalalgias (TACs), and new daily persistent headache.

As described by Rizzoli & Mullally (2018), migraines are typically characterized by moderate to severe throbbing or pulsating pain, often on one side of the head. Common accompanying symptoms include nausea, vomiting, sensitivity to light (photophobia), and sound (phonophobia). Some individuals experience an "aura" before or during a migraine, which typically involves visual disturbances, such as flashing lights or blind spots. Less frequently sensory and speech disturbances can also be observed. Migraine attacks can last for hours to several days. They are often described as severe and disabling, requiring individuals to lie down

in a dark, quiet room until the pain subsides. Migraines can be triggered by various factors, including but not limited to, specific foods (e.g., aged cheese, chocolate), hormonal changes (e.g., menstrual cycle), stress, lack of sleep, and weather changes. Migraines often have distinct phases including prodrome, aura, attack, and postdrome. Some individuals experience warning signs hours or days before a migraine, such as mood changes, food cravings, or fatigue known as prodrome. Some migraineurs experience aura including sensory disturbances that can affect vision, speech, or sensation. Not everyone with migraines experience auras. All migraineurs experience the headache phase, characterized by intense pain. After the attack, many individuals may feel exhausted or experience a "hangover" effect (Rizzoli & Mullally, 2018).

Rizzoli & Mullally (2018) specifies that tension-type headaches (TTHs) are the most common type of primary headache disorder and are characterized by a dull, aching pain, typically felt on both sides of the head. Pain can last for several hours, sometimes days. However, they typically do not last long. They are often described as a "band-like" pressure or tightness around the head. Unlike migraines, TTHs typically do not pulsate or throb, and they do not worsen with routine physical activity. The pain associated with TTHs is usually mild to moderate in intensity. Common triggers for TTHs include stress, anxiety, poor posture, and muscle tension in the neck and shoulders. TTHs are generally not disabling and do not typically interfere significantly with daily activities. However, TTHs can still be bothersome, and proper management is important for improving the quality of life for individuals affected by them (Rizzoli & Mullally, 2018).

Cluster headaches are a rare and excruciatingly painful type of primary headache disorder; due to their severity, they are sometimes referred to as "suicide headaches." (Rizzoli & Mullally, 2018). It is different from other types of headaches, such as migraines and TTHs, in

several ways. Cluster headaches are relatively rare, affecting a small percentage of the population. Interestingly, cluster headache is more common in men than women and often start in early adulthood. Cluster headaches are known for their intensity and severity. The pain is typically located on one side of the head and is focused around the eye, temple, or forehead. The pain is usually characterized as a severe, sharp, stabbing, or burning sensation. The pain occurs in cyclical patterns, with cycles of intense pain episodes that can last for several weeks or months, followed by periods of remission. During an active cluster period, individuals often experience multiple headaches per day, which can last from 15 minutes to 3 hours. Cluster headaches are often accompanied by autonomic symptoms on the affected side of the head (Rizzoli & Mullally, 2018).

Rizzoli & Mullally (2018) describe autonomic symptoms as:

- Redness and tearing of the eye (conjunctival injection and lacrimation)
- Nasal congestion or a runny nose (rhinorrhea)
- Drooping of the eyelid (ptosis) and constriction of the pupil (miosis).

Cluster headaches can have a profound impact on a person's quality of life, often leading to emotional distress and difficulty in daily activities (Rizzoli & Mullally, 2018).

Trigeminal autonomic cephalalgias (TACs) are a group of severe primary headache disorders characterized by excruciating, one-sided head pain and associated autonomic symptoms (Rizzoli & Mullally, 2018). These headaches are relatively rare and often challenging to diagnose. TACs include several specific headache disorders, the most well-known of which are: cluster headaches, paroxysmal hemicrania, short-lasting unilateral neuralgiform headache attacks with ipsilateral conjunctival injection and tearing (SUNCT), short-lasting unilateral neuralgiform headache with cranial autonomic symptoms (SUNA), and hemicrania continua

(Rizzoli & Mullally, 2018). These disorders share some common characteristics, such side-locked pain, and autonomic symptoms, but they also have distinct features that help differentiate them. Characteristics such as location, duration, and attack frequency are often used to differentiate among the different TAC disorders (Rizzoli & Mullally, 2018).

New daily persistent headache (NDPH) is another primary headache disorder that is characterized by the abrupt onset of a continuous and unremitting headache that occurs every day and persists for at least three months (Rizzoli & Mullally, 2018). Patients can often relay the exact date that the headache began. It is a rare but challenging condition to diagnose and treat. NDPH begins suddenly and without any apparent trigger, typically in individuals without a prior headache history (Rizzoli & Mullally, 2018).

The location of the headache can vary among individuals, but it is usually bilateral (Rizzoli & Mullally, 2018). The intensity of the pain can range from moderate to severe, and it often interferes with daily activities. NDPH may be accompanied by other symptoms, such as fatigue, neck pain, and difficulty concentrating. It is not typically associated with autonomic symptoms seen in other headache disorders like TAC disorders. NDPH can be chronic and refractory to treatment in some cases, making it a disabling condition. Interestingly, there are reported cases of spontaneous remission, where the headache completely resolves on its own (Rizzoli & Mullally, 2018).

Secondary Headaches

Secondary headaches are a category of headaches that occur as a symptom of an underlying medical condition or as a result of an external factor (Rizzoli & Mullally, 2018). These headaches are not primary headache disorders, but rather a secondary manifestation of

another health issue or an external trigger. These causes can be diverse and include various medical, neurological, or systemic issues.

Common underlying causes of secondary headaches include sinus infections, head or neck trauma, medication overuse, hypertension, infections of the central nervous system, brain tumors, temporomandibular joint disorders, dental problems, eye conditions (e.g., glaucoma), ear infections, substance withdrawal (e.g., caffeine withdrawal) (Rizzoli & Mullally, 2018). The characteristics of secondary headaches vary depending on the underlying cause. However, they can be similar to primary headaches. Making the accurate diagnosis of secondary headaches difficult (Rizzoli & Mullally, 2018).

It's essential to differentiate between primary and secondary headaches, as the approach to diagnosis and treatment differs significantly. Although overwhelmingly the majority of the headaches are going to be primary headache, it is crucial to promptly identify any underlying causes for headaches.

Variability of Emergency Management of Headache

Variability in management of headache can occur due to differences in clinical judgement, provider experience, hospital protocols, and patient preferences (Kelly et al., 2021). The assessment of headache in the ED is further complicated by the abundance of guidelines available. There are multiple guidelines such as the Australasian College for Emergency Medicine guidelines on diagnostic imaging, the American College of Emergency Physicians clinical policy in the evaluation and management of acute headache, and the UK guidelines (Kelly et al., 2021). There are also condition-specific clinical decision guidelines and treatment guidelines for specific conditions. A total of 4536 patients, from 67 hospitals, and 10 countries were studied by Kelly et al. (2021). There was a significant difference in the number of CT scans

ordered between nations (15.9%– 75.0%) (Kelly et al., 2021). The development of symptoms was gradual in more than half of the population studied (54.8%, 95% CI: 53.4%– 53.6%) (Kelly et al., 2021). Furthermore, 40.7% of patients (95% CI: 39.2%- 42.1%) reported experiencing nausea and/or vomiting (Kelly et al., 2021).

The main responsibility of the ED provider is to rule out significant pathology. As headache can be a sign of something more ominous. Often providers look for "red flags" to help determine which patients would benefit from advanced imaging. These "red flags" include positional headache, rapid or abrupt onset, older age, pattern change or recent development of new headache, history of neoplasm, neurologic deficit (including decreased level of consciousness), systemic symptoms like fever, and so forth (Kelly et al., 2021). In addition, it has been suggested that a fundoscopic examination can help determine whether advanced imaging is medically necessary. However, this study revealed that only 7.4% of the patients underwent a fundoscopy (Kelly et al., 2021). A lack of faith in the test, a lack of training in fundoscopy, as well as the ease of accessibility for neuroimaging, could all be contributing factors.

Overall, a disproportionately high percentage of headache patients who presented to the ED, received a non-contrast CT scan of the brain. This is likely due to providers not wanting to risk missing a critical diagnosis. However, the diagnostic tests were likely not indicated. A disproportionate 82.2% of head CT scans were deemed to be negative in this study (Kelly et al., 2021).

Impact of Provider Education

Provider education can have a positive impact on improving ED provider knowledge about headache management. Education can include updates on best practices, guidelines, and

the latest research in headache management. Benefits of such education may include improved diagnosis, reduced overuse of medication, increased patient satisfaction, reduced healthcare costs, and improved quality of life. Overall, provider education in headache management is essential for delivering high-quality care in EDs and improving patient outcomes.

This study consisted of a single-center, pre-post intervention study, in which a retrospective analysis was done on the medical histories of individuals who presented with headaches to the ED (Hervás et al., 2021). Thirty hospital trainees attended a training session led by the neurology service. The training session utilized the Spanish Headache Society Guidelines, along with a summary of the primary epidemiological and clinical characteristics of primary headaches, instructions on how to conduct a focused physical examination, and when to refer patients to neurology. A list of "red flags" and their necessary diagnostic tests was presented along with diagnostic-therapeutic algorithms. Medical histories from 2 months before, and 2 months after the training session were examined (Hervás et al., 2021).

A total of 469 medical histories were gathered, and after applying inclusion and exclusion criteria, 369 of them were chosen for further examination (Hervás et al., 2021). The pre-intervention group included 196 of the sample, and the post-intervention had 173 (Hervás et al., 2021). Following the intervention, the number of essential variables, pertaining to the documentation of pain characteristics included in the medical history increased from 4.34 ± 1.224 to 4.67 ± 1.079 ($P = .007$), and the overall number of items reported increased from 6.87 ± 1.982 to 7.53 ± 1.686 ($P = 0.001$) (Hervás et al., 2021). In the post-intervention group, there was an increase of 11.8% ($P = .002$) in the proportion of patients who received a specified primary headache diagnosis (Hervás et al., 2021).

Although this study had some limitations, including its small sample size, it is important to note that the study did not find any change between the pre-intervention and the post-intervention groups, regarding the number of additional exams. This writer is looking to decrease the overutilization of neuroimaging by increasing provider knowledge using a similar educational intervention.

Nonetheless, the history-taking process for headache patients in the ED was improved by this educational intervention. This characteristic makes educational interventions a potentially effective strategy for improving patient management in the ED.

Duration of Impact of Provider Knowledge

The effects of provider knowledge interventions can vary depending on various factors such as the type of intervention, the context in which it is applied, and the specific knowledge base being targeted. It was previously shown that an educational intervention can potentially improve the management of headache in the ED.

In a subsequent observational trial in southern Estonia, six general practitioners who previously received an educational intervention in headache management were studied. Two years following the educational intervention, the providers were studied for one full year. Data representing their practice were prospectively gathered. The referral rate (RR) to neurological services served as the major outcome metric. Comparisons were done using a previous study's baseline and post-intervention data (Braschinsky et al., 2017).

The RR was 19.9% in 366 patients who sought consultations throughout the follow-up period, which was lower than at baseline (39.5%; P 0.0001) or after the intervention (34.7%; P 0.0001) (Braschinsky et al., 2017). The RR varied by diagnosis, with migraine experiencing the greatest decrease of referrals. The use of terminologies for headache diagnosis revealed overall

shifts in favor of specific headache diagnosis. Particularly, the percentage of patients with migraine diagnoses grew significantly, and the erroneous M79.1 (Pericranial) myalgia diagnosis nearly completely disappeared (Braschinsky et al., 2017). Over 80% of the providers continued to initiate care for headache after the educational intervention (Braschinsky et al., 2017). Interestingly, diagnostic testing, which had decreased from 26% at baseline to 4% following the intervention, increased once again to 23% (Braschinsky et al., 2017). This writer is looking to impact the utilization of neuroimaging by increasing provider knowledge using an educational intervention.

Overall, following an educational intervention, improvements in healthcare provider practices can endure for three years or more, with some areas exhibiting even greater improvement (Braschinsky et al., 2017). This study did not find a lasting impact on healthcare provider behavior regarding diagnostic testing. In some cases, the effects may also be short-lived, especially if the intervention only involves a one-time training session or if the healthcare provider does not consistently apply the newly acquired knowledge.

To maximize the effectiveness of the knowledge intervention, this writer will consider ongoing reinforcement, monitoring, and support to ensure that healthcare providers continue to apply the knowledge in their practice. Additionally, the sustainability of the intervention's effects may also depend on the complexity of the knowledge being imparted and whether it aligns with best practices and guidelines in the field.

All in all, the duration of the effects of provider knowledge interventions can vary, and it is important to design interventions with sustainability in mind to achieve long-lasting improvements in healthcare practices.

Barriers and Facilitators

Provider education programs aimed at improving healthcare outcomes face several challenges and barriers. Identifying barriers and challenges allows for proactive planning to mitigate obstacles that might hinder the successful implementation of a QI project. Understanding these roadblocks is paramount to ensure a smooth implementation process. This writer utilized the information learned here to make informed choices about how to proceed with the knowledge intervention, how to modify it, and how to plan for long-term sustainability. The information obtained here allowed this writer to engage more effectively with key stakeholders.

Parmar et al. (2022), emphasizes the importance of having a carefully thought-out implementation strategy that takes into account stakeholder perceptions, organizational value, and culture. This review examined the crucial factors for putting healthcare innovation into practice.

The main facilitator was found to be multidisciplinary teams. Essentially, having both an external and internal promotor improves the smooth implementation of a quality improvement project (Parmar et al., 2022). Support from both upper administration and buy in by lower-level administration is paramount. Furthermore, the proposed change project needs to align well with the target population. Clinicians need to feel that the proposed change will improve their patient outcomes (Parmar et al., 2022). Flexibility was also found to be extremely helpful at the successful implementation of a quality improvement project. Providing training during times that were the most flexible, such as during lunch time, was found to increase the uptake by eligible participants (Parmar et al., 2022).

Some of the major barriers to the implementation was lack of information. It was found to be particularly helpful to provide evidence of efficacy of the proposed intervention (Parmar et al., 2022). Another barrier was the clinical workload. If the proposed intervention is considered

to be burdensome, there will be a significant pushback towards the implementation of the project (Parmar et al., 2022). Organizational hurdles can also impede the successful implementation of a project. Things like a rigid hierarchy with numerous approval steps or a lack of organizational readiness for change were found to be a major barrier (Parmar et al., 2022).

In summary, knowledge about barriers, challenges and facilitators is essential to informed decision-making, efficient stakeholder engagement, and the successful execution and sustainability of a QI project. This review provided an essential overview of considerations, which can be tailored to the context of this specific QI project.

Increased Utilization and Healthcare Costs

As alluded to earlier, over the past few years there has been a significant increase in the utilization of neuroimaging in the ED. This has been driven by advancement in technology, increased diagnostic capabilities in the ED, patient expectations, and risk for litigation (ElHabr et al., 2021). This trend raises the concern for cost-effectiveness and the need to optimize neuroimaging practices in the ED, especially as healthcare shifts towards value-based care (ElHabr et al., 2021).

ElHabr et al. (2021), utilized health claim information from Optum's Clinformatics Data Mart (CDM), a patient and provider deidentified database for beneficiaries of commercial and Medicare Advantage health plans. The claims data is geographically diverse, covering all of the continental United States (US). Claims that had both emergency services evaluation and management (EM) codes and CPT codes for neuroimaging were included. Data was analyzed retrospectively; however, age adjusted to account for an increasingly aging population. Age-adjusted ED neuroimaging use rates per 1000 ED visits grew 72% between 2007 and 2017 (ElHabr et al., 2021). This total increase corresponded to an increase of 69% in CT brain, 67% in

MRI brain, 1100% in CTA brain, 1300% in CTA neck, 36% in MRA brain, and 52% in MRA neck, as well as a drop of 8% in the use of carotid ultrasounds (ElHabr et al., 2021). Overwhelmingly, CT arteriogram usage in the ED has undergone a substantial growth. Interestingly, headache was one of the top five indications for ordering these diagnostic tests (ElHabr et al., 2021). This study does have some limitations as it could have been affected by coding errors or duplicate claims.

Although most clinical practice guidelines recommend against the use of routine imaging for headaches, and the increasing effort placed on efficiency in healthcare, such as the "Choose Wisely" campaign trends continue to rise (Callaghan et al., 2014). A study by Callaghan et al. (2014), neuroimaging was ordered in 12.4% (95% CI 10.5–14.7) visits with chief complaint of headache and 9.8% (95% CI 7.4–12.9) of visits with a chief complaint of migraine headache. In total, neuroimaging for headaches costs nearly $1 billion annually, and is use continues to increase (Callaghan et al., 2014).

In summary, neuroimaging of headaches is frequent, expensive, and probably substantially misused. The surge in neuroimaging has cost implications. Interventions to limit the use of these diagnostic tests have the potential to significantly decrease healthcare costs, increasing compliance with the established recommendations, and improving patient outcomes. It is paramount that clinicians balance the diagnostic benefits of neuroimaging with cost control. As more and more healthcare systems shift towards value-based care, there will be an increased pressure to optimize neuroimaging.

The increased use of CT scans in the emergency room can have several potential dangers and drawbacks. Increased radiation exposure can increase the risk of cancer overtime, especially with repeated scans. Minimizing unnecessary CT scans is crucial to reduce radiation exposure.

The overutilization of neuroimaging can lead to unnecessary costs, and over all a longer length of stay in the hospital. Overuse of CT scans can lead to false positives. CT scans can detect incidental findings not related to the patient's presenting symptoms. This can lead to unnecessary follow-up tests and anxiety for the patient. Notably, overreliance on neuroimaging can strain radiology departments and lead to delays in obtaining imaging for patients who truly need it. This study supports this writer's effort to minimize unnecessary neuroimaging through education on best practices.

Appropriateness Criteria for Neuroimaging

Healthcare providers may overutilize diagnostic imaging for several reasons including defensive medicine, uncertainty, patient expectations, and lack of time (Logsdon & Gleason, 2015). As a precaution to avoid potential legal issues clinicians may order extra tests. This practice is called defensive medicine, and it can lead to overutilization of diagnostic tests (Logsdon & Gleason, 2015). There are also cases where the diagnosis is unclear. Healthcare providers will often order multiple tests to rule out various life-threatening conditions, even when the likelihood of the condition is low (Logsdon & Gleason, 2015). Patients may also request specific tests or expect a certain level of testing, which can also influence the healthcare provider. Furthermore, in busy healthcare environments like the ED, providers often do not have the time for an extensive physical examination, leading to an overreliance on diagnostic tests (Logsdon & Gleason, 2015). The increased reliance on CT has to do with its ease of use, speed, and increased availability (Logsdon & Gleason, 2015).

The American College of Radiology has provided appropriateness criteria (ACR-AC) to help clinicians determine when diagnostic testing is warranted (Logsdon & Gleason, 2015). These are evidence-based guidelines developed and reviewed every 2 years by an expert

multidisciplinary panel. Criteria provides guidance with language such as “usually not appropriate,” “maybe appropriate,” and “usually appropriate.” Research suggests that clinicians may not be aware of the guidelines. A study with a descriptive survey design evaluated the awareness and utilization of the ACR-AC guidelines by advanced practice nurses (APNs) in the state of Florida (Logsdon & Gleason, 2015). The study showed that 75.94% of the APNs in the state of Florida were unfamiliar with the ACR-AC guidelines (Logsdon & Gleason, 2015). Similar studies have found that 81% of medical students have never heard of ACR-AC guidelines (Logsdon & Gleason, 2015).

This study clearly highlights the need to educate providers about imaging guidelines and cost-effective methods for delivering care. There is a knowledge gap and a need for educational programs to promote better patient outcomes by teaching about best practice guidelines. Perhaps even inserting ACR-AC into the electronic ordering system may help with increased appropriate ordering of diagnostic tests.

It has been demonstrated that there is inconsistency in the management of headache in the emergency room. Minimizing unnecessary imaging, is one of the primary goals of this QI project. Overutilization of imaging increases patient radiation exposure, cost, length of stay, and complications from incidental findings. Thus, overutilization of imaging is unlikely to improve patient outcomes; however, can potentially have detrimental effects.

Risk Stratification

Preventing overutilization of neuroimaging in the ED is essential to ensure efficient healthcare resource allocation and reduce unnecessary radiation exposure and costs. One method to prevent overutilization is risk stratification using red and green flags. This is a helpful approach for healthcare providers to identify potential underlying causes or concerning features

in headache presentations. Red flags indicate a higher risk of a serious underlying condition, while green flags suggest a lower likelihood of a serious issue (Do et al., 2021).

As Do et al. (2021) notes, red flags (indicating higher risk):

- Sudden and Severe Onset: A headache that develops suddenly and is extremely severe may raise concerns about serious conditions like hemorrhage or stroke.
- Change in Pattern: Any significant change in the pattern, frequency, or characteristics of a person's headaches, especially if it's a new type of headache for the individual, is a red flag.
- Neurological Symptoms: The presence of neurological symptoms such as weakness, numbness, visual disturbances, confusion, slurred speech, or difficulty walking should be considered a red flag.
- Fever: Headaches accompanied by high body temperature, especially if associated with neck stiffness, can be concerning for infections such as meningitis.
- Headache After Trauma: Headaches following trauma, particularly if there is loss of consciousness, vomiting, or changes in behavior, should be evaluated carefully for possible brain injury.
- Age: New-onset severe headaches in individuals over 50 years old or in children should raise concerns about secondary causes.
- Systemic Symptoms: Headaches associated with systemic symptoms such as weight loss, night sweats, or joint pain may indicate underlying medical conditions like autoimmune diseases.
- Cancer History: A personal history of cancer, or a family history of cancer and new-onset headaches, can be concerning for metastatic disease.

- Positional Headache: This is concerning for intracranial hypertension, or hypotension.
- Headache Precipitated by Sneezing, Coughing, or Exercise: This type of headache is concerning for posterior fossa lesions, Chiari malformation.
- Papilledema: Concerning for neoplasm and other non-vascular intracranial disorders.
- Pregnancy or Puerperium: Headaches attributed to cranial or cervical vascular disorders, post-dural puncture headache, hypertension-related disorders (e.g., preeclampsia), cerebral sinus thrombosis, hypothyroidism, anemia, and diabetes.
- Painful Eye with Autonomic Features: Pathology in posterior fossa, pituitary region, or cavernous sinus, Tolosa-Hunt syndrome, or ophthalmic causes (e.g., glaucoma).

As Do et al. (2021) notes, green flags (indicating lower risk):

- Typical Migraine Features: If a headache has typical features of a primary headache disorder like migraine (e.g., unilateral pain, pulsating quality, associated with nausea and sensitivity to light or sound), it may be a green flag, suggesting a lower risk of a serious underlying condition.
- Headache Free Days: Indicates periods of relief or remission from headache symptoms. It signifies that a person is experiencing relief from their usual headache symptoms and can resume their normal activities. It is a positive indicator of effective headache management or treatment.

- Stable Pattern: If a person has a long history of similar headaches with a stable pattern and no concerning features, it is less likely to be related to a serious condition (e.g., temporal relationship with menstrual cycle).
- Family History: A known family history of primary headaches is helpful in the context of diagnosing benign headache disorders. Having close relatives, such as parents or siblings, who experience migraines or cluster headaches, can increase the likelihood of someone developing migraines themselves. It's a valuable piece of information for healthcare professionals, when assessing a person's risk factors and can help with diagnosis.
- Onset of Headache: The more time passed since the onset of headache, the smaller the probability of a life-threatening secondary cause.

It's paramount to emphasize that the presence of red flags doesn't definitively diagnose a serious condition, but it warrants a thorough evaluation by a healthcare provider. Conversely, the absence of red flags doesn't exclude the possibility of underlying causes. Healthcare providers use these flags as guidelines to assess risk and make informed decisions about further evaluation and management of headaches (Do et al., 2021).

Clinical Algorithm

The trend toward imaging is growing despite numerous guidelines and studies showing that it is not cost-effective for treating individuals with non-traumatic headaches. The causes of this widespread trend are multifaceted. An algorithm to distinguish benign primary headaches from potentially serious secondary headaches may offer clinicians additional guidance and improve quality care (Jordan & Flanders, 2020). A thorough physical examination helps identify any red flags, such as neurological deficits or abnormal findings, which may indicate a secondary

headache. In cases with concerning symptoms, neuroimaging studies like CT scans or MRIs are used to rule out structural causes such as tumors, hemorrhages, or vascular abnormalities. Lumbar puncture may be considered in specific situations. This writer is looking to impact the overutilization of neuroimaging by increasing provider knowledge using an educational intervention. The ultimate goal is to improve patient outcomes. Jordan & Flanders (2020) provides valuable insight into the need for this QI project.

Headaches are a challenging clinical presentation. Clinical decision support (CDS) tools and artificial intelligence (AI) algorithms may help improve health outcomes (Jordan & Flanders, 2020). CDS systems are made to give healthcare providers the knowledge and situation specific information they need to make accurate clinical decisions. Computerized alerts, provider reminders, and on the spot clinical recommendations may be helpful at decreasing the overutilization of neuroimaging (Jordan & Flanders, 2020). The majority of CDS applications work as a part of the electronic health record, but more AI, and machine learning approaches are starting to power the newest CDS technologies (Jordan & Flanders, 2020).

Machine learning approaches are growing. In fact, one cross-sectional study found that an online, self- administered computer- based diagnostic tool was able to accurately diagnose patients with migraine, with an overall diagnostic accuracy of 91.6% (95% CI: 86.9%–95.0%), sensitivity of 89.0% (95% CI: 82.5%–93.7%), and specificity of 97.0% (95% CI: 89.5%–99.6%) (Cowan et al., 2022).

A computer-based diagnostic tool can be implemented within the healthcare system to assist ED providers in making accurate diagnoses, thereby lessening the overutilization of neuroimaging. These tools can decrease inefficiencies in headache management, which lowers

the cost of healthcare, reduces the time it takes to diagnose patients, and improves patient outcomes (Cowan et al., 2022).

Summary of the Evidence Related to the Clinical Question

Provider education plays a crucial role in improving ED clinician knowledge of headache management. The variability in ED headache management, the impact of provider education, and the duration of this impact are significant factors to consider. Barriers and facilitators, increased utilization, healthcare costs, appropriateness criteria for imaging, and risk stratification are also key considerations in enhancing headache management in the ED.

There is significant variability in how different ED providers diagnose and treat headaches, leading to inconsistent patient care. Provider education programs can improve the consistency and quality of headache management in the ED. The impact of provider education can be significant in the short term, leading to immediate improvements in headache management.

However, to sustain the gains and ensure long-term effectiveness, ongoing education and periodic updates are key. Barriers to effective provider education may include time constraints, limited resources, and resistance to change. Facilitators include strong leadership support, engaging educational methods, and provider buy-in. Provider education can help reduce healthcare costs by minimizing unnecessary tests and hospital admissions. It promotes the efficient use of resources by ensuring that costly interventions, such as imaging, are only used when appropriate. Overall, provider education in headache management can lead to more consistent, best practice care in the ED. This QI project has the potential to reduce healthcare costs, improve patient outcomes, and enhance the appropriate use of resources, ultimately benefiting both patients and healthcare systems alike.

Purpose

The goal is to improve clinician knowledge; thus, changing their practice habits. First providing clinicians with information to ensure they are up-to-date with the latest guidelines in headache medicine. The expectation is to improve clinician knowledge and promote consistent best practices in the management of headaches in the ED. This writer plans to carry out an educational intervention, including a pre-test and post-test. This design will allow the author to make comparisons between the target population — i.e., healthcare providers caring for headache patients in the ED, before and after the educational intervention.

PICO Question

- P (population): Headache Patients in the Emergency Department
- I (intervention): Headache Educational Intervention
- O (outcome): Increase Provider Knowledge
- C (comparison): Compared to Baseline Emergency Healthcare Provider Knowledge

Among patient's presenting to the emergency department with a chief complaint of headache (P), does the use of a headache educational intervention (I) increase emergency healthcare provider knowledge (O), when compared with baseline knowledge of the topic (C)? The primary aim for this project is to enhance patient outcomes by implementing a knowledge intervention.

Smart Objective

Smart goals consist of five key components: Specific, measurable, achievable, relevant, and timebound (Ogbeiwi, 2017). These goals are of paramount importance in QI projects. They provide a structured and systematic approach to setting and achieving objectives (Ogbeiwi, 2017).

- Specific: To reduce the variability in headache management, we will develop and implement a headache educational intervention.
- Measurable: Assess the improvement in healthcare professionals' knowledge and practices related to headache management through pre-and post-implementation evaluations.
- Achievable: We will form a task force consisting of neurologists, emergency department providers, and educators to collaboratively design the headache educational intervention, ensuring they are practical for our department's operations.
- Relevant: Reducing variability in headache management is crucial for improving patient care, satisfaction, and safety, while also minimizing legal and regulatory risks.
- Time-bound: Over the next 12 months, we will develop, implement, and evaluate the effectiveness of a headache educational intervention, with the aim of achieving an increase in ED provider knowledge.

Definition of Terms

Headache: A pain or discomfort in the head, scalp, or neck area.

Medication Overuse Headache (MOH): A type of headache that can result from the frequent use of headache medications, leading to worsening headaches.

Neuroimaging: Various non-invasive techniques and technologies that create detailed images of the structure and function of the brain and nervous system. These images are essential for diagnosing diseases. Common neuroimaging techniques include: magnetic resonance imaging (MRI), magnetic resonance angiography (MRA), magnetic resonance venography (MRV), computed tomography (CT) scan, computed tomography angiography (CTA) scan, and computed tomography venography (CTV) scan.

Magnetic Resonance Imaging Brain: An MRI brain, or magnetic resonance imaging of the brain, is a medical imaging technique that uses strong magnetic fields and radio waves to create highly detailed images of the brain's structure, helping diagnose various neurological conditions and providing valuable information for medical assessments.

Magnetic Resonance Angiography Brain: MRA brain, or Magnetic Resonance Angiography of the brain, is a specialized MRI technique that focuses on visualizing the blood vessels and blood flow in the brain. It is used to diagnose and assess vascular conditions in the brain, such as aneurysms or arteriovenous malformations.

Magnetic Resonance Venography Brain: MRV brain, or Magnetic Resonance Venography of the brain, is a specialized MRI technique that is used to visualize the veins and venous blood flow in the brain. It is often employed to diagnose conditions related to the brain's venous system, such as venous thrombosis or other vascular abnormalities.

Computed Tomography Brain: CT brain, or computed tomography of the brain, is a medical imaging procedure that uses X-rays to create detailed cross-sectional images of the brain, helping diagnose conditions like tumors, injuries, or bleeding in the brain.

Computed Tomography Angiography Brain: CTA brain, or Computed Tomography Angiography of the brain, is a medical imaging technique that combines CT scanning with the injection of a contrast dye to visualize the blood vessels and blood flow in the brain. It is used to diagnose and assess vascular conditions such as aneurysms, stenosis, or arterial blockages in the brain.

Computed Tomography Venography Brain: CTV brain, or Computed Tomography Venography of the brain, is a medical imaging technique that uses CT scanning with contrast dye to visualize the veins and venous blood flow in the brain. It helps to diagnose and assess

conditions related to the brain's venous system, such as venous thrombosis or other vascular issues.

Knowledge Gap: Refers to a deficiency or lack of information, understanding, or awareness about a particular topic or subject. It represents the difference between what is known and what needs to be known to address a specific issue or make informed decisions.

Conceptual Underpinning and Theoretical Framework

The framework used to guide this QI project is "Lean Six Sigma." Lean Six Sigma is a data-driven approach that focuses on process improvement and reducing variation (Kam et al., 2021). It combines two distinct methodologies, Lean and Six Sigma, to identify and eliminate defects, reduce waste, and improve efficiency in various processes (Kam et al., 2021).

The lean methodology was originally used in the automobile manufacturing industry; however, in the recent years it has been used to address the growing issues in the healthcare field (Kam et al., 2021). Lean is primarily focused on minimizing waste in processes, thus increasing efficiency. It identifies seven types of waste: over-production, waiting, over-processing, rework, unnecessary human motion, inventory, and unnecessary transportation (Kam et al., 2021). Inappropriate use of diagnostic neuroimaging can be considered a waste of over-production. Lean principles aim to eliminate these wastes through streamlined processes, reduced resource utilization, and improved workflow. This results in faster delivery, lower costs, and improved patient outcomes.

Six Sigma, originally developed by Motorola in 1986, is a structured methodology for improving the quality of processes by reducing variation and defects (Kam et al., 2021). The term "Six Sigma" refers to a statistical level of quality control that allows only 3.4 defects per

million opportunities (Bertolaccini et al., 2015). The methodology consists of five steps: Define, Measure, Analyze, Improve, and Control phases (Bertolaccini et al., 2015).

Lean and Six Sigma are integrated to leverage the strengths of both methodologies to enhance process efficiency and quality. The Lean principles address waste reduction, while Six Sigma focuses on reducing variation and defects (Rathi et al., 2022). This author seeks to reduce the variation in headache management in the ED, while at the same time reducing wasteful use of diagnostic testing, such as MRI when not indicated. Lean and Six Sigma allows for process improvement and the achievement of quality patient outcomes, while minimizing resource utilization. This methodology is increasingly being used to optimize healthcare processes, enhance patient satisfaction, and reduce operational costs (Rathi et al., 2022). It provides a structured framework for problem-solving, data-driven decision-making, and ongoing quality improvement efforts.

Methodology

Setting and Participants

The study took place at a tertiary care facility, Emergency Department. The study participants were emergency department healthcare providers including physicians and advanced practice providers (APPs). Dr. Maike Blaya, a board-certified Neurologist and Headache Specialist was the mentor for this doctoral nursing student. The QI project entailed an educational intervention regarding headache management. The goal was to increase the knowledge of emergency department providers; thereby, achieving improved patient outcomes.

Description of the Approach

This writer first conducted an initial survey via Qualtrics to assess the baseline knowledge among emergency room providers regarding headache management. We then

delivered the educational intervention. The informational materials were shared with the target population using a voice-over PowerPoint. The aim was to improve provider knowledge of headache management, including imaging considerations for headache patients. We subsequently administered a post-intervention test, also via Qualtrics, to assess the knowledge gained after the educational intervention.

Protection of Human Subjects

This QI project did not pose any risks to the well-being of the participants, whether in terms of mental, physical, social, or economic aspects. Participation in this project was voluntary. Informed consent was implied by providers participating in the study. The survey materials clearly stated that by responding to the questions and completing the survey, they agreed to participate in the research study. However, the materials accompanying the questionnaire did not require that the subject sign a consent form. Participants only had to click "I agree to participate" once entering the online survey questionnaire. Participants maintained the right to withdraw from the study at any time without facing any adverse consequences. All data collected was anonymized to ensure the privacy and confidentiality of the participants. Confidential information was securely stored and shared only with the project team. We obtained Institutional Review Board (IRB) approval from both Florida International University and Memorial Healthcare System. This ensured that the research design adhered to ethical standards.

Data Collection Procedure

Data such as basic demographic information about the participating healthcare providers, such as age, gender, years of experience, and specialty was collected. Pre-test data was collected, including responses to a pre-test questionnaire to gauge the baseline knowledge of providers. Post-test data including responses to a post-test questionnaire to assess the knowledge gained

after the educational intervention was also collected. Implementation data such as participation rates was collected. Records of approvals and communications with IRBs were kept demonstrating compliance with ethical standards.

Data Management Plan

All project team members received training in data handling and adhered to ethical and legal considerations related to data management. Data was securely stored on a dedicated, password-protected laptop computer and Qualtrics database accessible only to the project team. Access to data was restricted to project team members who required it for analysis and reporting. Security measures were maintained to protect participant data.

Laptop was locked when not in use. All data transmission and storage were encrypted to protect against unauthorized access of sensitive information. Data will be retained after project completion, as required by institutional policies. After this defined period, data will be securely archived for potential future research use or destroyed in compliance with data protection regulations.

Timeline

This timeline ensured that the key project activities were completed within a 6–7-month period.

Project Initiation: (Months 1 to 4)

- Task 1: Assemble the project team.
- Task 2: Design and develop educational materials and program content.
- Task 3: Develop the pre-and-post intervention knowledge assessment questionnaire.
- Task 4: Obtain necessary institutional review board approvals and permissions.

Project Implementation: (Months 4 to 6)

- Task 6: Administer the pre-intervention knowledge assessment to participating providers.
- Task 7: Collect and analyze baseline knowledge data.
- Task 8: Rollout the educational voice-over PowerPoint.
- Task 9: Administer the post-intervention knowledge assessment.
- Task 10: Collect and compile post-intervention knowledge data.
- Task 11: Analyze pre- and post-intervention test scores.

Wrapping up: (Month 7)

- Task 12: Summarize and document the project's results and findings.
- Task 13: Prepare a report on the impact of the educational intervention.
- Task 14: Present the project results.
- Task 15: Develop recommendations for future research and/or sustaining the gains.

This timeline was designed to accommodate the essential project tasks within a 6–7-month timeframe. As is the case with any QI project, the writer-maintained flexibility and was prepared to adjust the schedule to align with project goals and address unexpected obstacles, as needed.

Results

The original sample consisted of 19 participants, representing a diverse demographic profile across various categories:

- Age Distribution: Participants ranged predominantly between 35 to 54 years old, with 53% falling within the 45-54 age group.

- Gender Composition: The sample was predominantly male, comprising 68% of the participants.
- Ethnicity: The majority of the participants identified as Caucasian (58%), followed by Hispanic (21%) and other ethnicities (16%).
- Years of Experience in Emergency Medicine: The sample included a range of experience levels, with a significant portion (37%) having 16-20 years of experience, and a notable representation (21%) with 21 or more years of experience.
- Position/Title: Physicians constituted the largest group (79%), with smaller proportions of Physician Assistants/Associates (11%), Nurse Practitioners (5%), and other positions (5%).

This demographic breakdown provides a comprehensive overview of the sample characteristics that informed the study's findings.

Table 1

	Demographic Range	**% of participants (n=19)**
Age	18-24	0%
	25-34	11%
	35-44	26%
	45-54	53%
	55-64	11%
	65+	0%
	Gender	**% of participants (n=19)**
Gender	Male	68%
	Female	32%

	Other	0%
	Ethnicity	**% of participants (n=19)**
Ethnicity	Hispanic	21%
	Caucasian	58%
	African American	0%
	Asian	0%
	Other	16%
	Prefer not to answer	5%
	Range of years	**% of participants (n=19)**
Years of Experience Emergency Medicine	Less than 1 year	5%
	1-5 years	16%
	6-10 years	11%
	11-15 years	11%
	16-20 years	37%
	21+ years	21%
	Position/Title	**% of participants (n=19)**
Position/Title	Physician	79%
	Physician Assistant/Associate	11%
	Nurse Practitioner	5%
	Other	5%

Throughout the project, some participants were lost due to various reasons. After a period exceeding three weeks, the number of participants who fully completed the pre-test was (n=14) and the post-test was (n=6). Participant attrition occurred for various reasons. Likely factors included scheduling conflicts, loss of interest, and acts of nature. Despite efforts to maintain

engagement and follow-up, there was a reduction in the final number of respondents for the QI project.

This reduction in the sample size posed significant challenges, affecting the strength of the statistical analyses and potentially limiting the ability to detect meaningful relationships or effects. The loss of participants also introduced concerns regarding bias, as those unable to continue may have differed systematically from those who remained, impacting the representativeness of the findings. To address these challenges, the interpretations were adjusted accordingly, emphasizing transparency in reporting to mitigate the impact of participant attrition on the study's validity and reliability.

Table 2

SURVEY	MIN SCORE	MAX SCORE	MEAN	STANDARD DEVIATION
PRE-INTERVENTION	8	19	13.71	2.74
POST-INTERVENTION	15	20	17.00	1.53

Pre-test data was collected to gauge the baseline knowledge of healthcare providers regarding headache management. The pre-test scores ranged from a minimum of 8 to a maximum of 19, with a mean score of 13.71 and a standard deviation of 2.74. This indicates a moderate level of variability in the baseline knowledge among the providers, with scores spread around the mean.

Following the educational voice-over PowerPoint intervention, post-test data was collected to assess the knowledge gained by the providers. The post-test scores showed an

improvement, with scores ranging from a minimum of 15 to a maximum of 20. The mean score increased to 17.00 with a reduced standard deviation of 1.53, suggesting a higher level of knowledge and a more consistent understanding among the providers after the intervention.

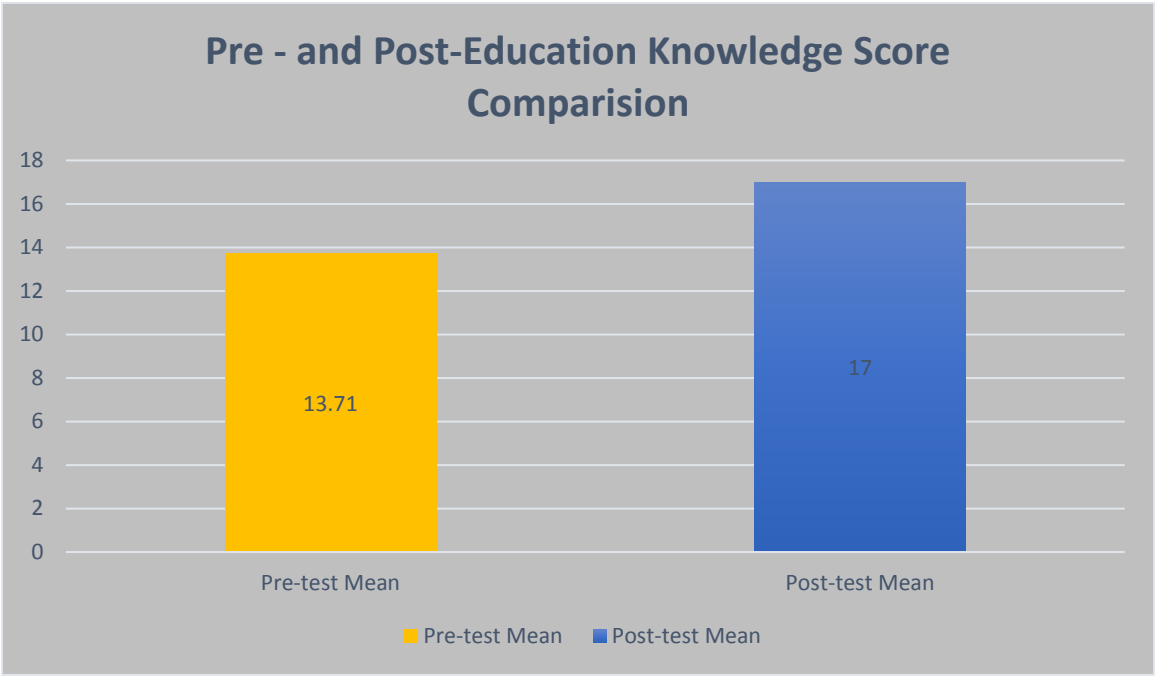
However, it is important to note that there was a significant decrease in the sample size between the pre-test and post-test. This reduction in sample size could influence the findings in several ways:

- Generalizability: With a smaller post-test sample, the results may not be as representative of the overall population of emergency department healthcare providers. This reduction could limit the ability to generalize the findings to a broader context.
- Statistical Power: A smaller sample size decreases the statistical power of the analysis, making it more challenging to detect true differences or effects. This could potentially lead to an underestimation of the intervention's impact.
- Bias: The decrease in sample size might introduce bias if the dropouts were not random. For example, if those who did not complete the post-test had systematically different baseline knowledge or engagement levels, this could skew the results.

Despite these limitations, the comparison between pre-test and post-test scores still demonstrates a notable improvement in the providers' knowledge. The increase in the mean score from 13.71 to 17.00 indicates that the educational intervention was effective in enhancing the providers' understanding of the appropriate use of imaging for headache patients. Additionally, the decrease in the standard deviation from 2.74 to 1.53 reflects a more uniform level of knowledge post-intervention, suggesting that the educational content was well-received and comprehended similarly by the participants.

In conclusion, while the statistical analysis highlights the positive impact of the educational intervention on the knowledge of healthcare providers, the significant decrease in sample size between the pre-test and post-test must be considered when interpreting the findings. Further studies with larger and more consistent sample sizes would be beneficial to confirm these results and enhance their generalizability.

Figure 1



In the context of evaluating the significance of this educational intervention, a one-tailed Wilcoxon signed-rank test was conducted with a sample size of six pairs of observations (n = 6). The test aimed to determine whether there was a significant increase in scores post-intervention. The calculated W value was 2. According to the critical values for a one-tailed test at a significance level of alpha = 0.05, the critical W value for (n = 6) is 2. Since the obtained W value is exactly at the critical threshold, this result indicates marginal significance. Therefore, we reject the null hypothesis, concluding that there is a statistically significant difference between

the pre- and post-intervention scores, suggesting that the educational intervention had a positive impact on the participants' knowledge levels.

Table 3

	Headache Specific Trainings Within the Last Year	**% of participants (n=19)**
Headache Specific Trainings	None	53%
	1	21%
	2	16%
	3	0%
	More than 3	5%
	I don't know/I don't remember	5%
	Headache Specific Trainings with Neuroimaging Considerations	**% of participants (n=11)**
Headache Specific Trainings with Neuroimaging Considerations	None	18%
	Yes, some of the content.	73%
	Yes, a lot of content.	9%

The data collected also suggests a varied level of engagement in headache-specific trainings, with a majority not participating or having limited recall of such trainings in the past year. However, a notable proportion of the participants who engaged in headache specific training sessions received neuroimaging considerations, highlighting a growing integration of advanced diagnostic concepts in educational programs.

Table 4

CONFIDENCE IN ORDERING APPROPRIATE IMAGING	PRE-TEST	POST-TEST
VERY CONFIDENT	8.33%	33%
CONFIDENT	58.33%	50%
NEUTRAL	33.33%	17%
NOT VERY CONFIDENT	0%	0%
NOT CONFIDENT AT ALL	0%	0%

The results indicate a positive shift in confidence levels after the intervention. Specifically, there was an increase in the proportion of participants who reported feeling "Very confident" in ordering appropriate imaging (from 8.33% to 33%). Although the proportion of participants who felt "Confident" slightly decreased (from 58.33% to 50%), this change was accompanied by a decrease in the proportion of participants who were "Neutral" (from 33.33% to 17%). Overall, these findings suggest that the educational intervention had a beneficial effect on enhancing confidence in ordering appropriate imaging among the participants.

Table 5

CONFIDENCE DIAGNOSING HEADACHE DISORDERS	PRE-TEST	POST-TEST
VERY CONFIDENT	8.33%	33%
CONFIDENT	50%	50%
NEUTRAL	33.33%	17%
NOT VERY CONFIDENT	8.33%	0%
NOT CONFIDENT AT ALL	0%	0%

The results indicate a notable increase in participants' confidence levels in diagnosing headache disorders following the intervention. Specifically, the percentage of participants reporting being "Very Confident" increased from 8.33% to 33%, suggesting a positive impact of the intervention on confidence levels. Conversely, the proportion of participants feeling "Neutral" or "Not Very Confident" decreased post-intervention. These findings highlight the effectiveness of the educational intervention in enhancing participants' confidence in diagnosing headache disorders.

Discussion

The results indicate a notable improvement in knowledge scores following the knowledge intervention. The increase in mean score from 13.71 to 17.00 indicates that the educational intervention effectively enhanced providers' understanding of headache management. Additionally, the decrease in standard deviation from 2.74 to 1.53 reflects a more uniform level of knowledge post-intervention, suggesting that the educational content was well-received and comprehended similarly by the participants. This outcome emphasizes the effectiveness of educational interventions at improving healthcare provider knowledge.

In the context of evaluating the significance of the QI project, a one-tailed Wilcoxon signed-rank test was conducted. The test aimed to determine whether there was a significant increase in scores post-intervention. The Wilcoxon signed-rank test results suggest that the educational intervention had a positive impact on the participants' knowledge levels regarding headache management.

Furthermore, feedback gathered indicated a significant improvement in participants' confidence levels in diagnosing headache disorders and ordering appropriate imaging. This

improvement in confidence aligns with the observed increase in knowledge scores and magnifies the practical benefit of the educational intervention in enhancing both knowledge and self-efficacy among healthcare providers.

Limitations

Several limitations merit consideration. First, the small sample size pre-test (n=14) and the post-test (n=6), limits the generalizability of the findings. The loss of participants also raises concerns regarding bias, as those unable to continue may have differed systematically from those who remained, impacting the representativeness of the findings. Further studies with larger and more consistent sample sizes would be beneficial to confirm these results and enhance the generalizability.

Implications for Advanced Nursing Practice

The findings of this QI project emphasize profound implications for advanced nursing practice. By illustrating the efficacy of interventions designed to enhance healthcare providers' knowledge, this study reenforces the opportunities APNs have to enhance the quality and safety of patient care. The project’s findings contribute to the broader evidence base in nursing, potentially influencing future QI initiatives. APNs are well positioned to champion for initiatives that address critical knowledge gaps. This project provides further evidence to suggest that APNs should continue to act as change agents, advocating for and actively participating in quality initiatives and continuous professional development programs. These efforts are essential for enhancing healthcare outcomes and ensuring patient safety.

Conclusion

In conclusion, the QI project demonstrates that targeted educational interventions can significantly enhance emergency department providers' knowledge of headache management. Despite limitations, the findings support the implementation of similar educational initiatives to improve patient care outcomes and provider competency in clinical settings. Future research could benefit from a larger sample size to strengthen the validity and reliability of the results. Additionally, the short-term follow-up limits insights into the long-term retention and application of knowledge gained from the intervention. Longitudinal studies could provide insights into the sustainability of the knowledge improvement and its impact on clinical outcomes over time.

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Appendices

Appendix A: IRB Approval Letters

FIU | Research & Economic Development
FLORIDA INTERNATIONAL UNIVERSITY

MEMORANDUM

To: Dr. Eric Fenkl

CC: Christopher Arocha

From: Carrie Bassols, BA, IRB Coordinator CeB

Date: February 26, 2024

Proposal Title: "A Clinical Algorithm and an Educational Intervention Regarding Headache Management to Increase the Knowledge of Emergency Department Providers in a Tertiary Care Facility – A Quality Improvement Project"

The Florida International University Office of Research Integrity has reviewed your research study for the use of human subjects and deemed it Exempt via the **Exempt Review** process.

IRB Protocol Exemption #:	IRB-24-0077	**IRB Exemption Date:**	02/26/24
TOPAZ Reference #:	113932		

As a requirement of IRB Exemption you are required to:

1) Submit an IRB Exempt Amendment Form for all proposed additions or changes in the procedures involving human subjects. All additions and changes must be reviewed and approved prior to implementation.
2) Promptly submit an IRB Exempt Event Report Form for every serious or unusual or unanticipated adverse event, problems with the rights or welfare of the human subjects, and/or deviations from the approved protocol.
1) Submit an IRB Exempt Project Completion Report Form when the study is finished or discontinued.

Special Conditions: N/A

For further information, you may visit the IRB website at http://research.fiu.edu/irb.

Memorial Healthcare System
INSTITUTIONAL REVIEW BOARD

3501 Johnson Street, Hollywood, FL 33021
Phone: (954) 265-1857 | E-mail: irb@mhs.net
FWA: 00003898 | IRB Registration: 00003075

March 21, 2024

Maike Blaya, MD
Neuroscience MOB, Suite 650

IRB Project#: MHS.2024.050
Project Title: A Clinical Algorithm and an Educational Intervention Regarding Headache Management to Increase the Knowledge of Emergency Department Providers in a Tertiary Care Facility – A Quality Improvement Project
Submission Type: Non-Human Subjects Research Application – Initial Review (Ref # 009742)

Dear Investigator:

The Memorial Healthcare System Institutional Review Board (IRB) has reviewed the proposed activity referenced above and determined that it does not meet the definition of research with human subjects as outlined in 45 CFR 46.102 or 21 CFR 56.102. Therefore, IRB oversight is not necessary. Please note that you are still required to follow all applicable institutional and HIPAA policies and ethical guidelines. Additional details regarding this determination are provided starting on page 2 of this letter. Please review each page carefully.

Sincerely,

Signature applied by Lukasz Fiedorowicz on 03/21/2024 09:03:21 PM EDT

Luke Fiedorowicz, Ph.D.
IRB Director
Memorial Healthcare System

IRB DETERMINATION

Project does not meet the definition of research with human subjects as outlined in 45 CFR 46.102 or 21 CFR 56.102.

This non-human subjects research determination applies only to the project described in the application referenced above. Any changes to the project (including scope, objectives, methodology, or publication plan) may affect the determination. It is the responsibility of the Principal Investigator (PI) to submit any changes to the project to the MHS IRB for review prior to implementation.

SUBMISSION COMPONENTS

The following items have been reviewed as part of this submission:

Submission Components			
Form Name		Version	Outcome
Initial Review		Version 1.0	Acknowledged
Non-Human Subject Research Determination		Version 1.0	Acknowledged
Study Document			
Title	Version #	Version Date	Outcome
CITI Certificate Arocha HIPS	Version 1.0	03/17/2024	Acknowledged
CITI Certificate Arocha	Version 1.0	03/17/2024	Acknowledged
Florida International University IRB Exemption Approval Letter	Version 1.0	03/17/2024	Acknowledged
Pretest and Posttest Questionnaire	Version 1.0	03/17/2024	Acknowledged
Recruitment Email	Version 1.0	03/17/2024	Acknowledged
MRH Letter of Support	Version 1.0	03/17/2024	Acknowledged

The latest submission packet can be downloaded from the MHS IRB System (irb.mhs.net). The PI is responsible for keeping records of all IRB correspondence, including outcome letters and IRB stamped documents.

CONFLICTING IRB MEMBERS

The following IRB members did not participate in the review of this project due to Conflict of Interests: **None**

Thank you for complying with the Memorial Healthcare System Institutional Review Board policies

Appendix B: Letter of Support

Memorial Healthcare System

MEMORAL REGIONAL HOSPITAL • MEMORAL REGIONAL HOSPITAL SOUTH • JOE DIMAGGIO CHILDREN'S HOSPITAL
MEMORIAL HOSPITAL WEST • MEMORIAL HOSPITAL MIRAMAR • MEMORIAL HOSPITAL PEMBROKE

Date: 1/25/24

Eric A. Fenkl, Ph.D., RN, CNE
Associate Professor with Tenure
Nicole Wertheim College of Nursing & Health Sciences
Florida International University

Dear Dr. Fenkl,

Thank you for inviting Memorial Regional Hospital to participate in the Doctor of Nursing Practice (DNP) project conducted by Christopher Arocha entitled "A Clinical Algorithm and an Educational Intervention Regarding Headache Management to Increase the Knowledge of Emergency Department Providers in a Tertiary Care Facility – A Quality Improvement Project." I understand that this student will be conducting this project as part of the requirements for the Doctor of Nursing Practice program at Florida International University. I have warranted him permission to conduct the project in this company, using our providers.

This quality improvement project aims to improve healthcare professionals' knowledge related to headache management, through a 20–30 minute voiceover PowerPoint educational module. Pre-and post-implementation evaluations will be used to determine the efficacy. The target population will consist of approximately 15 to 50 healthcare providers working at Memorial Regional Hospital, emergency department. Participants will be provided with an electronic link leading them to complete an anonymous pre-and-post intervention survey. The survey is not expected to take more than 10 minutes to complete. The evaluations will be delivered via Qualtrics, an online survey product.

We understand that participation in the study is voluntary and carries no overt risk. All emergency department providers are free to participate or withdraw from the study at any time. Responses to the surveys are not linked to any participant. The collected information is reported as an aggregate, and there is no monetary compensation for participation. All collected material will be kept confidential, stored in a password - encrypted digital cloud, and only be accessible to Christopher Arocha. We expect that Christopher Arocha will not interfere with normal hospital performance, behave in a professional manner, and follow standards of care. Prior to the implementation of this educational project, the Florida International University, Institutional Review Board will evaluate and approve the procedures to conduct this project. This scholarly project's execution will occur over two weeks. We support the participation of our Emergency Department providers in this project and look forward to working with you.

Respectfully,

Randy S. Katz, DO, MBA, FACEP
District Medical Director
Emergency Services – Memorial Healthcare System

Appendix C: Recruitment Email

Recruitment Email

A Clinical Algorithm and an Educational Intervention Regarding Headache Management to Increase the Knowledge of Emergency Department Providers in a Tertiary Care Facility – A Quality Improvement Project

Greetings,

My name is Christopher Arocha, and I am a student from the Graduate Nursing Department at Florida International University. I would like to invite you to participate in a quality improvement project, that I am conducting in partial fulfillment of the requirements for the degree of Doctor of Nursing Practice. This project aims to improve healthcare professionals' knowledge related to headache management, through a 20–30 minute voiceover PowerPoint educational module. Participants will be provided with an electronic link leading them to complete an anonymous pre-and-post intervention survey. The survey is not expected to take more than 10 minutes to complete.

You are eligible to take part in this project because you are a healthcare provider at the Emergency Department at Memorial Regional Hospital. I am contacting you with the permission of your Medical Director. If you decide to participate in this project, you will complete a questionnaire, which is expected to take no more than 10 minutes. Then, you will be asked to review a short educational module (voiceover PowerPoint). After its completion, you will be asked to complete the post-test questionnaire, which is expected to take no more than 10 minutes.

Participation in this study is completely voluntary. You are free to participate or withdraw from the study at any time. Responses to the surveys are not linked to any participant. The collected information is reported as an aggregate, and there is no monetary compensation for participation. If you'd like to participate, please reply to this email stating your willingness to participate. By responding to the survey questions, you are agreeing to participate in this research study. If you have any questions about the study, please feel free to contact me at CAroc008@fiu.edu or (305)469-7195.

I truly appreciate your time and consideration in this matter. Thank you very much.

Sincerely,

Christopher Arocha, MSN, APRN, FNP-BC

Appendix D: Pretest and Posttest

Pretest and Posttest Questionnaire:

Headaches

INTRODUCTION

The objective of this quality improvement (QI) project is to improve emergency department clinician proficiency in acute headache management with a key goal to optimize the utilization of neuroimaging techniques. The primary end goal is improving patient outcomes in this population.

Please answer the questions below to the best of your ability. The questions are either in multiple choice or true/false format. These questions are meant to measure the knowledge and perceptions on the identification and management of headache.

PERSONAL INFORMATION

1. **Gender:** Male Female Other
2. **Age:** 18-24 years 25-34 years 35-44 years 45-54 years 55-64 years 65+ years
3. **Years of experience in emergency medicine**: Less than 1 year 1-5 years
   6-10 years 11-15 years 16-20 years 21+ years
4. **Ethnicity:** Hispanic Caucasian African American Asian Other
   Prefer not to answer
5. **Position/Title:** Physician Physician Assistant/Associate Nurse Practitioner Other

6. How many trainings (in any format: in-person, or virtual) have you attended in the **past year** that focused on headache?

   None 1 2 3 More than 3 I don't know/I don't remember

7. If you did attend a training, did the content include considerations for neuroimaging?

   N/A No Yes, some of the content. Yes, a lot of content.

QUESTIONNAIRE

1. **What does the presence of red flags in headache presentations indicate?**

A. A lower risk of a serious underlying condition

B. A higher risk of a serious underlying condition

C. Neither

2. **Which of the following best defines overutilization of imaging?**

A. Proper and judicious use of imaging techniques

B. Excessive and unnecessary use of imaging procedures

C. Limited application of imaging technologies

D. Timely and appropriate utilization of imaging methods

3. **Which of the following is a potential consequence of overutilization of imaging?**

A. Decreased patient radiation exposure

B. Increased cost and hospital length of stay

C. Improved patient outcomes

D. Fewer complications from incidental findings

4. How does risk stratification using red and green flags contribute to preventing the overutilization of neuroimaging?

A. By facilitating the identification of specific indicators or warning signs that warrant neuroimaging.

B. By promoting awareness of potential risks and benefits, guiding appropriate imaging decisions.

C. By aiding in the efficient allocation of healthcare resources.

D. All of the above

5. What is the role of the American College of Radiology's appropriateness criteria (ACR-AC)?

A. Setting emergency department protocols

B. Guiding diagnostic testing based on evidence

C. Determining patient eligibility for imaging

D. Recommending medication for headache management

6. Which of the following is a limitation of the American College of Radiology's appropriateness criteria (ACR-AC)?

A. It updates its recommendations every 10 years

B. It is not evidenced-based

C. It does not include vessel imaging in its recommendations

D. It does not include recommendations for when contrast should be used

E. It does not recommend disease-specific protocols

7. What distinguishes secondary headaches from primary headaches?

A. Recurrent nature

B. Autonomic symptoms

C. Severity of pain

D. Specific underlying causes or medical conditions

E. All of the above

F. None of the above

8. What is one of the defining characteristics of Trigeminal Autonomic Cephalalgias (TACs)?

A. Unilateral severe headache pain.

B. Bilateral discomfort with tension.

C. Chronic, diffuse head pain.

D. None of the above

9. Cluster headaches are sometimes referred to as "suicide headaches."

A. True

B. False

10. What imaging is recommended as the initial diagnostic test for a patient suspected of having a trauma-related headache with a potential bleed?

A. Non-contrast head CT scan

B. Non-contrast head MRI

C. PET scan

D. Contrast enhanced head CT scan

E. Doppler ultrasound

11. For persistent or positional pain suggestive of Idiopathic Intracranial Hypertension (IIH) or CSF leak, what diagnostic test will provide the most useful information?

A. CTA head and neck

B. MRI brain without gadolinium

C. MRI brain with gadolinium

D. PET Scan

12. A 27-year-old male presents to the emergency department for evaluation of a severe headache. He has a past medical history of chronic migraines for 3 years that he describes as severe and throbbing headaches associated with photophobia, phonophobia, and nausea. His headache is unilateral, R>L, over the frontal and periorbital region. His headache is almost always preceded by an aura of zig-zags and flashes of light in his vision. He has tried several preventive medications over the years with each one providing only moderate symptomatic relief. He was started on topiramate 2 weeks ago by his outpatient neurology provider and is now on 25 mg twice daily. He reports that over the past 3 days he has had a severe right periorbital headache with light sensitivity and that his vision in the right eye is slightly blurred with rainbow halos around lights. On examination, he has a fixed dilated pupil on the right. Which of the following is the most appropriate next step?

A. Order IV ketorolac with metoclopramide and diphenhydramine

B. Obtain urgent neurology consultation

C. Obtain urgent ophthalmology consultation for sit-lamp examination and gonioscopy

D. Increase topiramate dose to 50 mg twice daily with outpatient follow-up with neurology

E. Order MRI brain

F. Order MRI of the orbits

G. Both E and F

13. A 25-year-old female presents with a recurrent moderate to severe intensity headache, associated with visual disturbances and nausea. The patient reports a family history of migraines. Physical examination is unremarkable. How would you approach this scenario?

A. Perform imaging studies to rule out underlying pathology.

B. Admit for observation in the short-stay unit.

C. Diagnose as a migraine with aura based on symptoms and family history and initiate appropriate management.

D. Consult neurology for specialized headache management.

14. Which of the following is included in the International Classification of Headache Disorders (ICHD)-3 criteria for migraine?

A. Nausea or vomiting

B. Photophobia or osmophobia

C. Allodynia

D. Improvement with activity

E. Unilateral autonomic symptoms

15. A 22-year-old male presents to the emergency department with concerns about his neurologic status. He has episodic throbbing, unilateral headache, associated with nausea and photophobia. Never seen a healthcare provider for his headaches in the past. Major concern today, even after the throbbing headache resolves, he feels partially impaired by symptoms of 1 to 2 days of irritability, fatigue, and cognitive cloudiness, affecting his performance in school. Patient's mother who is a healthcare provider is requesting neuroimaging because she feels there must be something wrong. What is the best way to approach this scenario?

A. Order CT brain without IV contrast

B. Order MRI brain without IV contrast

C. Reassure the patient and family that this is a typical migraine headache with associated postdrome symptoms, outpatient follow-up with neurology is advised

D. Consult neurology for specialized headache management

16. A 65-year-old female with a past medical history of chronic migraine presents to the emergency room with a chief complaint of severe headache. She reports that she experienced the worst, most severe headache of her life last night that was unlike her typical migraine episodes. The headache remained intense for about three minutes and then slowly improved over time. Headache is currently moderate in intensity with associated neck discomfort. Patient is concerned because her mother passed away from a stroke 3 years ago. On examination, blurring of the optic disk margins is seen bilaterally. Which of the following is NOT considered a red flag or indicator of a secondary headache type in this scenario?

A. Change in headache characteristics

B. Family history of stroke

C. Onset after age 50

D. Papilledema

E. Thunderclap onset

F. All of the above

G. None of the above

17. **A new patient has presented to your emergency department with a chief complaint of headache. What information would NOT suggest the need for imaging?**

A. Onset after age 50

B. Headache aggravated by position

C. New headache reaching maximum intensity within a minute

D. Recent head trauma

E. Stable headache pattern with periods of pain freedom

18. Options for headache imaging encompass: MRI, MRA, MRV, CT, CTA, CTV. The selection of the appropriate modality is contingent upon various factors, with the exclusion of which of the following?

A. Age

B. Headache intensity

C. Papilledema

D. Suspected cluster headache

E. Time to maximum intensity

19. A 30-year-old female who is 26 weeks' gestation presents to the emergency department with 3 days of headache that was acute in onset and has progressed in

intensity daily. On examination, she has bilateral papilledema. Which diagnostic test will provide the most useful information?

A. STAT CT Brain without contrast

B. MRA Brain without contrast

C. MRV Brain without contrast

D. None of the above

20. A 25-year-old male presents to the emergency room with a chief complaint of migraine-like headache attack of rapid onset with orgasm. He has a history of migraine and typically experiences about four attacks per month, which respond well to rizatriptan. The patient reports a family history of migraines. Physical examination is unremarkable. The most appropriate course of action is?

A. Reassure him that this is migraine episode

B. Tell him that this symptom means that he will need to abstain from sexual activity

C. Direct him to take his triptan one hour prior to sexual activity, prophylactically

D. Order imaging to rule out subarachnoid hemorrhage, arterial dissection, and reversable cerebral vasoconstriction syndrome.

21. Which set of symptoms is most effective in differentiating migraine from tension-type headache?

A. Bifrontal head pain, moderate pain level, with light and sound sensitivity

B. Bifrontal head pain, with a moderate pain level

C. Light and sound sensitivity, with nausea or vomiting, worsened by physical activity, pulsating quality, and moderate pain level

D. Moderate pain level, with associated nausea or vomiting

E. Worsened by physical activity

22. How confident do you feel in diagnosing various headache disorders?

A. Very confident

B. Confident

C. Neutral

D. Not very confident

E. Not confident at all

23. Please rate your confidence in ordering appropriate imaging for headache disorders.

A. Very confident

B. Confident

C. Neutral

D. Not very confident

E. Not confident at all

24. How frequently do you order imaging studies (e.g., MRI, CT scans) for patients with headache symptoms and normal neurological examination?

A. Very frequently

B. Frequently

C. Occasionally

D. Rarely

E. Never

25. How often do you encounter patients reporting headaches in your practice?

A. Rarely

B. Occasionally

C. Frequently

D. Very frequently

Appendix E: Evidence Table

Study	Focus	Findings	Design
Rizzoli & Mullally, 2018	Current diagnosis and classification of headache disorders	- Migraine: Characterized by moderate to severe throbbing pain, often one-sided, with accompanying symptoms such as nausea, sensitivity to light and sound, and possible aura. Tension-type headaches: Present with dull, aching pain, usually bilateral, without pulsating quality. - Trigeminal autonomic cephalalgias (TACs): Characterized by severe, one-sided head pain with associated autonomic symptoms. - Various types of daily headache, including new daily persistent headache (NDPH): Involves continuous headache occurring daily for at least three months without typical migraine features. - Secondary headaches: Result from underlying medical conditions or external factors, with diverse causes such as sinus infections, head or neck trauma, medication overuse, hypertension, and substance withdrawal. - Differentiating between primary and secondary headaches is crucial for appropriate diagnosis and management.	Narrative Review

Kelly et al., 2021	Epidemiology of nontraumatic headache in adults presenting to emergency departments (EDs)	- 4536 patients enrolled from 67 hospitals across 10 countries. - "Thunderclap" onset noted in 14.2% of cases. - Severe headache reported in 27.2% of cases. - New neurological examination findings uncommon (3.2%). - Head CT performed in 36.6% of patients, with 9.9% showing clinically important pathology. - Wide variation in CT scan utilization between countries (15.9% -75.0%). - Various diagnoses made, with presumed nonmigraine benign headache accounting for 45.4% of cases and migraine for 24.3%. - Small subgroup of patients (7.1%) had serious secondary causes for their headache, including subarachnoid hemorrhage (SAH), stroke, neoplasm, non-SAH intracranial hemorrhage/hematoma, and meningitis. - Most patients treated with simple analgesics and discharged home (83.8%). In-hospital mortality was 0.3%.	Observational, Cross-sectional Study
Hervás et al., 2021	Impact of training session on headache management at the emergency department (ED)	- Training session focused on history-taking and primary headaches' diagnoses and management at the ED.	Observational Study (Retrospective Comparison)

		- Retrospective analysis comparing medical reports before and after training. - 369 medical histories analyzed (196 before, 173 after training). - Post-intervention, an increase in essential variables regarding pain characteristics included in medical reports (4.34 ± 1.224 to 4.67 ± 1.079, p = .007). - Increase in total items registered (6.87 ± 1.982 to 7.53 ± 1.686, p = 0.001). - Percentage of patients diagnosed with a specific primary headache increased by 11.8% post-intervention (p = .002). - Educational interventions improve history-taking in headache patients in the ED, potentially optimizing patient management.	
Braschinsky et al., 2017	Duration of effect of structured education of general practitioners (GPs) on headache management	- Follow-up observational study in southern Estonia assessing the duration of effect of structured education on headache management. - Subjects were six GPs managing patients presenting with headache as the main complaint. - Data collected prospectively over a 1-year period, commencing 2 years after the educational intervention.	Observational Study (Follow-up)

		- Primary outcome measure was referral rate (RR) to neurological services. - RR during follow-up period (19.9%) lower than baseline (39.5%) and post-intervention (34.7%) rates. - Changes in diagnosis-dependent RR, with the biggest decline observed for migraine. - Increased use of specific headache diagnostic terms, particularly for migraine diagnoses. - Decrease in inappropriate diagnostic term (M79.1 Pericranial myalgia). - Resurgence in requests for investigations, primarily laboratory investigations. - Initiation of treatment by GPs remained high (just over 80%). - Improvements in GPs' practice lasted for ≥3 years, with some further enhancements observed. - Evidence suggests the need for repeating educational programs every 2-3 years for sustained impact.	
Parmar et al., 2022	Facilitators, barriers, and considerations for implementation of a novel healthcare innovation	- Systematic review following PRISMA guidelines, examining facilitators, barriers, and considerations for implementing a novel healthcare innovation.	Systematic Review

		- Thematic analysis of 28 articles identified major themes related to facilitators, barriers, and recommendations for implementation. - Five key considerations for implementation identified: research and information sharing, intentional implementation planning, organizational underpinnings, creating the clinical context, and facilitative training. - Provides insights and recommendations for developing tailored implementation strategies in healthcare settings.	
ElHabr et al., 2021	Evaluation of changing emergency department (ED) utilization of neuroimaging from 2007 through 2017	- Utilized patient-level claims data from Optum's Clinformatics Data Mart database to assess annual ED utilization rates of various neuroimaging modalities from 2007 through 2017. - Age-adjusted ED neuroimaging utilization rates per 1000 ED visits increased 72% overall during the study period. - Head and neck CTA showed the most significant growth, with rates increasing by 1100% and 1300%, respectively. - Head CT remained the dominant neuroimaging examination. - Utilization of head CT and CTA increased	Observational Study (Retrospective Analysis)

		significantly in enrollees 65 years old or older. - Rapid growth of head and neck CTA observed across both commercially insured and Medicare Advantage populations. - The appropriateness of this growth should be monitored as indications for CTA expand.	
Callaghan et al., 2014	Evaluation of neuroimaging utilization in outpatient headache visits in the United States.	- Utilized National Ambulatory Medical Care Survey (NAMCS) data to assess neuroimaging utilization in outpatient headache visits from 2007 through 2010. - Neuroimaging obtained in 12.4% of all headache visits and 9.8% of migraine visits. - Total neuroimaging expenditures estimated at $3.9 billion over 4 years, including $1.5 billion from migraine visits. - Neuroimaging utilization increased significantly from 1995 to 2010, from 5.1% to 14.7% of all annual headache visits. - Considerable overuse of neuroimaging suggested, given the low yield of significant abnormalities in patients with chronic headaches. - Efforts to curb utilization, such as guidelines and the Choosing Wisely campaign, may be more effective if	Observational Study (Retrospective Analysis)

		targeting patient education and cost-sharing strategies.	
Logsdon & Gleason, 2015	Perceived knowledge and educational preparedness of advanced practice nurses (APNs) in radiological imaging.	- Evaluated perceived knowledge and educational preparedness of APNs in radiological imaging, including awareness and utilization of American College of Radiology Appropriateness Criteria (ACR-AC). - Majority of APNs (75.9%) had never heard of the ACR-AC. - Years of experience and training in acute care specialties increased perceived competency in ordering radiological tests. - Similar findings to studies on medical students, residents, and hospitalists regarding need for further education in radiological imaging. - 92.3% of respondents stated additional APN imaging education would be beneficial. - Highlights importance of incorporating more radiological imaging information into APN education to improve perceived competence and knowledge of appropriate imaging utilization.	Observational Study
Do et al., 2021	Updates in the diagnostic approach of headaches.	- Review summarizing updates in the diagnostic approach of headaches to facilitate the distinction	Narrative Review

		between primary and secondary etiology. - Emphasizes the importance of a systematic diagnostic approach using red flags and green flags to reduce unnecessary testing and improve patient care. - Calls for further validation of diagnostic concepts for clinical use.	
Jordan & Flanders, 2020	Challenges in appropriate imaging of patients with headache.	- Challenges in appropriate imaging of patients with headache. - Review discussing challenges in appropriate imaging of patients with headache, despite guidelines demonstrating lack of cost-effectiveness. - Reasons for overuse of imaging include fear of missing significant lesions, litigation concerns, patient pressures, and financial motivations. - Calls for regulatory and legislative reforms to encourage best practices without fear of professional sanctions. - Suggests the value of negative findings on imaging tests requires better understanding and proposes clinical decision support tools and machine intelligence for guidance.	Narrative Review
Cowan et al., 2022	Concordance in migraine diagnosis between online, self-administered CDE and	- The study enrolled 276 participants, of which 212 completed both the semi-structured interview (SSI) and the computer-based diagnostic Engine (CDE),	Observational, Cross-sectional Study

	semi-structured interview.	yielding a completion rate of 77%. - The concordance in diagnosing migraine/probable migraine (M/PM) between SSI and CDE was found to be high, with a Cohen's kappa coefficient of 0.83 (95% CI: 0.75-0.91). - The CDE demonstrated excellent diagnostic accuracy, with a sensitivity of 90.1% and specificity of 95.8%. Positive and negative predictive values were 97.0% and 86.6%, respectively, based on an identified migraine prevalence of 60%. When assuming a general migraine population prevalence of 10%, the positive and negative predictive values remained high at 70.3% and 98.9%, respectively. - The study findings indicate that the SSI and CDE exhibit strong agreement in diagnosing M/PM. The CDE's high specificity and positive likelihood ratio facilitate ruling in M/PM, while its high sensitivity and low negative likelihood ratio aid in ruling out M/PM. - Thus, a CDE that mirrors SSI logic emerges as a valid tool for migraine diagnosis.	