

PROVIDER-DIRECTED EDUCATION TO REDUCE UNNECESSARY NEUROIMAGING  
IN UNCOMPLICATED HEADACHE DISORDERS: A QUALITY IMPROVEMENT  
PROJECT

DNP Final Project

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## Abstract

### Background:

Over 1.9 million annual outpatient visits to neurologists in the U.S. are associated with headache diagnoses. For uncomplicated headache disorders, the evidence-based practice (EBP) guidelines recommend against neuroimaging unless specific neurological signs and symptoms are present. However, neuroimaging rates in this patient group have only modestly decreased since the guidelines were developed. The purpose of this quality improvement project was to reduce unnecessary neuroimaging in patients with uncomplicated headache disorders by implementing a provider-directed educational session about the EBP guidelines for neuroimaging in patients with uncomplicated headaches.

### Methods:

A 15-minute provider-directed educational session focusing on uncomplicated headache disorders and the EBP guidelines for neuroimaging use in this patient population was presented orally and in-person to all general neurology providers (n =9) in a large urban outpatient neurology clinic. The providers were given an electronic version of the presentation and a pocket-sized EBP algorithm for neuroimaging use in patients presenting with uncomplicated headache symptoms.

### Results:

Data collected from the project site's neuroimaging dashboard showed a significantly lower proportion of unnecessary neuroimaging orders in the 8-week post-educational interval (4.2%) compared to the 8-week pre-education interval (7.2%) ( $t = 2.78, p = 0.014$ ), a 41.6% reduction.

Conclusions:

This project's findings indicate a provider-directed educational session reviewing the EBP guidelines for neuroimaging in patients with uncomplicated headache disorders was successful in lowering rates of a low value-service in a large urban outpatient neurology clinic. Implementing similar projects in other departments (e.g., primary care clinics) could further reduce unnecessary neuroimaging use across the organization.

Provider-directed Education to Reduce Unnecessary Neuroimaging in Uncomplicated Headache Disorders: A Quality Improvement Project

**Section I: Nature of the Problem**

A large proportion of patients evaluated in outpatient neurology clinics in the United States present with the chief complaint of headache. Data from the National Ambulatory Medical Care Survey show that over 1.9 million annual outpatient visits to neurologists are associated with a headache diagnosis (Burke, Skolarus, Callaghan, & Kerber, 2013; CDC/National Center for Health Statistics, 2015). In the recent past, patients with uncomplicated headache disorders (e.g., migraine headaches, tension headaches, and chronic migraine headaches) were mostly managed empirically; however, since 1995, the use of neuroimaging with computed tomography (CT) of the head or magnetic resonance imaging (MRI) of the brain in this patient population has increased dramatically (5.1% in 1995 to 14.7% in 2010) (Callaghan, Kerber, Pace, Skolarus, & Burke, 2014). To address the rising neuroimaging rates and related costs, the American Academy of Neurology (AAN), the American College of Radiology (ACR), and Choosing Wisely®, an initiative launched by the American Board of Internal Medicine Foundation in 2012 to focus on reducing unnecessary tests, established evidence-based recommendations for neuroimaging use when assessing patients with headaches. However, the overall rates of unnecessary neuroimaging associated with headache diagnoses have only modestly decreased since the recommendations were developed (Rosenberg et al., 2015). Thus additional messaging strategies are needed to facilitate change in provider practice patterns.

Providers in the Emory Healthcare's general neurology outpatient department evaluate the majority of patients entering the healthcare system with headache complaints and thus reducing the rate of unnecessary neuroimaging has been a priority for the department since 2015. To

facilitate this initiative a quality improvement project was designed and aligned with the organization's core values of caring, excellence, integrity and value. The primary aim of the project was to decrease unnecessary neuroimaging in patients with uncomplicated headache disorders through a provider-directed educational session about the evidence-based practice guidelines for neuroimaging.

### **Background**

Neuroimaging in patients with uncomplicated headaches or headaches without a secondary cause does not aid in diagnosis or treatment and as such, has been deemed a low-value service or a service that provides little to no patient benefit (Charlesworth, Meath, Schwartz, & McConnell, 2016). Multiple factors contribute to the overuse of neuroimaging services by providers including: practice patterns, the perception that neuroimaging will allay patients' fears, self-referral incentives for neuroimaging, and concerns about potential litigation related to a missed diagnosis (Callaghan et al., 2015; Hong, Ross-Degnan, Fang, Wharam, & Zhang, 2017). However, the unnecessary overuse of neuroimaging services creates ethical, policy, and organizational challenges. For example, increased demand for neuroimaging services can lead to longer wait times for patients needing imaging services and increase out-of-pocket costs with high-deductible insurance plans. Moreover, the potential detection of incidental findings can cause unwarranted emotional distress.

Given that many healthcare organizations across the country have reported steadily rising rates of neuroimaging associated with headache-related diagnoses, the AAN and the ACR developed evidence-based guidelines for neuroimaging use in this patient population in 2014 (American Academy of Neurology, 2014; Douglas et al., 2014). Both organizations agreed that neuroimaging in patients with uncomplicated headache disorders is generally not warranted

except when certain symptoms or specific findings become evident during the neurological assessment (American Academy of Neurology, 2014; Douglas et al., 2014). Additionally, Choosing Wisely®, a group consisting of internal medicine physicians, family medicine physicians, and pediatricians that joined forces with specialists to evaluate low-value services, published patient and provider recommendations for neuroimaging in 2012. These guidelines emphasize the use of neuroimaging in patients with uncomplicated headaches disorders should be carefully considered and should not be ordered in patients with stable headaches that meet the diagnostic criteria for migraine headache (Loder, Weizenbaum, Frishberg, Silberstein, & Force, 2013). The joint recommendations from these professional organizations aim to assist providers with clinical decision-making when evaluating patients with headaches. However, neuroimaging rates have only modestly decreased since the practice recommendations became available to healthcare providers (Rosenberg et al., 2015).

Currently, there is no national benchmark for unnecessary neuroimaging rates. However, Vizient, formerly known as the Voluntary Hospitals of America and the University Health Systems Consortium, a member-driven organization created to aid healthcare systems in providing high-quality cost-effective care will assess a healthcare system's neuroimaging rates and compare the data to peer institutions. According to Vizient, the current benchmark for standards of unnecessary neuroimaging in the Emory Healthcare system is less than 9%. Although Emory's unnecessary neuroimaging rate was reported as less than 9% in 2018, the goal for the organization was to reduce the frequency by an additional 20%. Therefore this quality improvement project was undertaken with support from key stakeholders, (the neurology department and Emory Healthcare's quality improvement team). They too were interested in determining if an educational session about the evidence-based practice guidelines delivered to

providers in the out-patient neurology department would reduce the number of unnecessary neuroimaging orders associated with uncomplicated headache diagnoses over time.

## **PICO**

The purpose of this project was to reduce unnecessary neuroimaging in patients with uncomplicated headache by delivering an educational session to providers based on the evidence-based recommendations. The clinical question was “In neurology providers (*Population*) how does a provider-directed educational session (*Intervention*) compared to no provider education session (*Comparison of interest*) affect neuroimaging utilization in patients with uncomplicated headaches (*Outcome*).”

## **Significance**

In 2015, President Obama signed the Medicare Access and Children’s Health Insurance Reauthorization Act (MACRA) of 2015, taking healthcare one step further toward value-based care. The Merit Based Incentives Payment System (MIPS) associated with MACRA aims to achieve a value-based care model with positive and negative financial incentives based on care quality. The reimbursement changes associated with MACRA are designed to improve quality in healthcare. Reducing unnecessary neuroimaging in patients with uncomplicated headache is an approved quality indicator in the AAN’s Axon Registry®, an approved qualified clinical data registry (QCDRs) that is used in the MIPS program. Projects aiming to reduce unnecessary neuroimaging in patients with uncomplicated headaches through educational interventions could lead to the positive financial incentives associated with the MIPS program and reduce the risk of negative financial incentives if quality indicators are not met.

## **Project Objectives**

Emory Healthcare’s core values include caring, excellence, integrity, and value (Emory

Healthcare, 2017). The quality improvement project aligned with these core values, as this project improved the value of care provided to patients by reducing unnecessary testing. Additionally, this project improved organizational excellence by applying evidence-based care in the outpatient neurology clinic. There were four objectives of this quality improvement project:

1. Implement a provider-directed educational session about uncomplicated headache disorders and the EBP recommendations for neuroimaging in patients presenting with symptoms of uncomplicated headaches.
2. Determine the level of provider knowledge about neuroimaging ordering in this population before and after the session.
3. Determine the rate of unnecessary neuroimaging related to uncomplicated headache diagnosis in the neurology department before and after the educational session.
4. Improve utilization of neuroimaging in uncomplicated headache through EBP change.

By focusing on value and excellence the quality improvement project supported the core values of Emory Healthcare and improved the care patients receive.

## **Section II: Review of the Literature**

Due to the challenges associated with unnecessary neuroimaging, multiple organizations have created recommendations for neuroimaging use in patients with uncomplicated headache. In 2014, the AAN and ACR published recommendations for neuroimaging in uncomplicated headache. Both organization agree that neuroimaging in patients with uncomplicated headache is generally not warranted unless the patient has certain signs and symptoms (American Academy of Neurology, 2014; Douglas et al., 2014). In 2012, Choosing Wisely® published patient and provider recommendations suggesting that the use neuroimaging in patients with the diagnosis of



uncomplicated headache should be carefully considered in patients presenting with migraine headache (Loder et al., 2013). All three recommendations aimed to assist providers with clinical decision-making when considering neuroimaging in uncomplicated headache syndromes.

### **Searching for Evidence**

Multiple databases were searched for relevant literature on reducing unnecessary neuroimaging in patients with uncomplicated headache by using two key words, “uncomplicated headache” and “imaging.” Inclusion criteria included: “2012-2017,” “Peer-Reviewed,” “English,” and “human.” The databases searched included: CINAHL (Cumulative Index to Nursing and Allied Health Literature), PubMed, Cochrane, and PsychINFO. Through this search twenty-six records were identified. Professional websites such as the AAN and Choosing Wisely® were examined for recommendations. Through this general search three records were identified on the AAN website and one record was identified through the Choosing Wisely® site.

**Screening.** Twenty-nine records were screened. Four duplicate records were removed.

**Eligibility.** Twenty-three full-text records were assessed for eligibility using the rapid critical appraisal tool (Helene Fuld Health Trust National Institute for Evidence-based Practice in Nursing and Healthcare, 2018). Two multimedia records were assessed for eligibility. Eighteen records were excluded, as they did not correlate to the project PICOT question or, in the case of the multimedia records, a more complete record of the same information was identified.

**Included.** Seven articles were included in the synthesis (see appendix A). All articles represent systematic reviews, literature reviews, quantitative studies, or quality measures.

### **Detailed Evidence Review**

The Choosing Wisely® initiative is a group of internal medicine physicians, family

medicine physicians, and pediatricians that joined forces with specialists to evaluate low-value care. In 2012 Choosing Wisely® collaborated with the AHS to create recommendations for headache medicine entitled, “Choosing Wisely in Headache Medicine: The American Headache Society’s List of Five Things Physicians and Patients Should Question.” Their first two recommendations focused on neuroimaging. The joint manuscript recommends against neuroimaging in cases without abnormal neurologic findings (Loder et al., 2013).

In 2014 the AAN released their most up-to-date recommendations for headache, “Headache Quality Measures Set.” The AAN agreed with the Choosing Wisely recommendations, suggesting that providers should order neuroimaging in cases of abnormal neurologic findings (American Academy of Neurology, 2014). The AAN further recommends neuroimaging for patients with coexisting seizures, change in previously diagnosed headache, HIV, immunodeficiency, coagulopathies or on anti-platelet therapy, and unexplained symptoms in patients who are very young (American Academy of Neurology, 2014).

In 2014 the ACR released their “ACR Appropriateness Criteria Headache.” The ACR uses a 1-9 rating scale with 1-3 suggesting that imaging is usually not appropriate, 4-6 suggesting that imaging may be appropriate, and 7-9 suggesting that imaging is usually appropriate. While the ACR rated MRI with and without contrast as a 4 in patients with chronic headache and no neurological abnormality, their criteria for when imaging may be appropriate aligned with the AAN and Choosing Wisely® suggesting that imaging is recommended in patients with an abnormal neurologic exams, seizures, and immunodeficiency (Douglas et al., 2014).

The Choosing Wisely® and AHS recommendations, AAN Headache Quality Measures Set, and ACR Appropriateness Criteria were further supported by Katz’s (2016) manuscript. Katz supports avoiding imaging in the patient with uncomplicated headache and created a

clinical article focusing on when and when not intervention is indicated in the patient with headache (Katz, 2016). Current evidence clearly supports that neuroimaging is not indicated in patients with uncomplicated headache; however, overutilization continues to be problematic.

The effects of the Choosing Wisely® initiative have been studied and while these recommendations have modestly decreased neuroimaging in uncomplicated headache the clinical significance of these recommendations have been questioned. Rosenberg et al. (2015) evaluated seven of the Choosing Wisely® recommendations. His team noted that there was a modest statistically significant improvement in the use of low-value services; however, the team suggested that provider data feedback, educational interventions, and systems support is needed to further reduce the use of low-value services (Rosenberg et al., 2015). Moreover, Hong et al. (2017) evaluated clinician level predictors of use of low-value services and noted that clinicians' previous ordering patterns were a predictor of future use of low-value services. The information gained from Hong et al. and Rosenberg et al. supports the use of educational interventions aimed at providers to reduce the use of low-value services, as further intervention is needed to change current provider practice patterns.

The overuse of low-value services is not simply a financial issue. Cote and Laws (2017) identify that there are ethical considerations when ordering low-value services. Overuse of low-value services has the potential to increase healthcare costs and reduce access to care by utilizing services in patient populations without a clinical benefit (Cote & Laws, 2017). Moreover, the psychological impact of excess imaging or potential downstream intervention for an incidental finding cannot be understated, as in the case of a false-positive finding (Cote & Laws, 2017). The patient related anxiety to such a finding outweighs any perceived benefit of ordering unnecessary neuroimaging. Overuse of low-value services negatively affects the ethical

principals of justice and non-maleficence and use should be carefully considered, as there is no morally correct theory to justify the use of low-value services.

### **Section III: Methods**

#### **Framework for Quality Improvement**

The Iowa Model (see appendix B) was used in the design phase of this project because of its clear step-by-step method to promote quality care and implement evidence-based practice change within a healthcare system (Buckwalter et al., 2017). There are several components within the Iowa Model that play pivotal roles in ensuring support for and overcoming barriers to the project. The Iowa Model recommends that users match a clinical problem with an evidence-based intervention to create change (Brown, 2014). The quick pairing of a clinical problem with evidence-based interventions streamlines project development and focuses the scope of the project. The Iowa model also emphasizes the importance of obtaining organizational support from key stakeholders and organizing an interprofessional team to ensure that projects will be successfully supported throughout the organization.

#### **Project Design**

This project used a pretest-posttest design to evaluate the impact of a provider-directed educational session about the evidence-based guidelines for neuroimaging use in patients with headaches on the rate of unnecessary neuroimaging orders over an eight-week interval of time. The educational session aimed to improve provider knowledge about the guidelines and reduce the number of unnecessary neuroimaging orders associated with uncomplicated headache diagnoses. The project was granted exempt status through the organization's institutional review board. The project team included a neurologist and a family nurse practitioner.

#### **Practice Setting**

The Emory Clinic's outpatient general neurology department in Atlanta, Georgia was the

setting for this project. It was chosen because providers in this department evaluate the majority of patients presenting to the Emory Healthcare System with headache complaints. Data from the neuroimaging dashboard showed that there were 1,544 individual patient encounters in the general neurology department from June 2018 to August 2018 that correlated with a diagnosis of uncomplicated headache.

### **Practice Environment - Providers**

Providers completing the education session included nurse practitioners (NPs) and physicians practicing in the general neurology outpatient clinic. All providers in this clinic evaluate new patients and NPs, physicians, or the physician-NP team assess patients returning for follow-up visits.

### **Education Session**

The project leader (NP) delivered the education session that included the definition of uncomplicated headaches according to the AAN's headache quality measures set, the evidence-based clinical practice guidelines (CPG) (see appendix C) for neuroimaging in patients with uncomplicated headache disorders, and an explanation of the evidence-based practice algorithm (see appendix D) that was developed by the project leader specifically for the providers included in this project. The information was presented orally and in-person, supplemented with PowerPoint slides, to all the general neurology providers during the mandatory monthly program meeting (November 2018) at the neurology outpatient clinic. As such, all providers employed in the clinic were included in the project and received the educational session at the same time. At the end of the educational session, each provider was presented with the evidence-based practice algorithm (laminated index card) and a flash drive containing the electronic version of the presentation, the CPG, and the algorithm.

**Questionnaire**

Providers' knowledge about neuroimaging use for patients with uncomplicated headache disorders was assessed before and after the educational session using an evidence-based questionnaire developed by the project team. The questions asked were specific to uncomplicated headache disorders and based on the AAN, ACR, and Choosing Wisely® recommendations. The providers accessed and completed the questionnaire electronically via Qualtrics, an online survey software platform, immediately before and after the educational session. The pre-session version of the questionnaire contained three questions and the post-session version included the same three questions and two additional questions designed to elicit opinions specifically about the quality and perceived value of the educational session.

**Data Collection**

Data regarding the number of neuroimaging orders associated with an uncomplicated headache diagnosis initiated in the outpatient neurology clinic were collected for a sixteen-week interval – eight weeks immediately before the educational session and eight weeks shortly after the educational session, with a 28-day window to ensure all neuroimaging orders had been completed. Data collection was accomplished via the project site's neuroimaging dashboard. The neuroimaging dashboard uses an algorithm based on ICD-10 coding information to identify patients within the system evaluated for uncomplicated headache disorders who received neuroimaging and then generates the rate of unnecessary neuroimaging in this population. Neuroimaging data sets were limited to patients evaluated by providers in the neurology outpatient department. Data were collected with the assistance of the project site's data analytics department and stored within a Microsoft Excel toolkit.

De-identified pretest-posttest data were retrieved from the Qualtrics software system and

then transferred to a PDF file. All project-related data were stored on a secure, password-protected Emory Healthcare System computer.

### **Data Analysis**

A paired *t*-test was conducted to compare neuroimaging orders associated with uncomplicated headache disorders during the eight-week interval before and after the educational session. The analysis did not compare neuroimaging orders initiated by physicians versus NPs to reduce the risk for potential bias when analyzing the data and to report the findings. A paired *t*-test was also conducted to compare the scores from the two questionnaires.

## **Section IV: Findings**

### **Provider Demographics**

The general neurology providers included in this project ( $n = 9$ ) had been practicing at Emory Healthcare for an average of 6.9 (SD = 4.48) years (Table 1). Three of the providers were female and six were male. Seven of the providers have a medical degree, and two providers have a master's degree.

### **Questionnaire**

There were no significant differences between the scores on the pre- and post-session questionnaires. All providers scored 100% on both the pre- and post-test evidence-based portion of the questionnaire and either agreed or strongly agreed that the educational session met their learning needs and that the instructor created an environment conducive to learning (see appendix E).

### **Neuroimaging orders**

The within-group analyses showed that the average number of neuroimaging orders in the eight-week interval after the education session was significantly lower than in the eight-week

range before the session ( $t=2.78, p=0.014$ ). Specifically, data from the pre-session interval demonstrated that 7.2% of neuroimaging orders were unnecessary, while only 4.2% of the orders were classified as unnecessary in the post-session interval, a 41.6% reduction (see appendix F and G).

### **Section V: Recommendations and Implications for Practice**

The rising rates and associated costs of unnecessary neuroimaging in patients with uncomplicated headache disorders negatively impact patients, healthcare providers and healthcare systems. The findings from this quality improvement project suggest that an educational session for neurology providers about neuroimaging use in uncomplicated headache disorders may reduce unnecessary neuroimaging rates. The data show an overall reduction of 41.6% in neuroimaging orders in the eight-week interval immediately after the educational session compared to the eight-week interval before the educational session.

In 2018, the price for a non-contrast CT of the head at Emory Healthcare was \$1997.00, and the price for an MRI of the brain with and without contrast was \$4,031.00. The estimated cost savings in patient charges associated with the neuroimaging rate reduction demonstrated in this project are between \$112,000 and \$226,000 (based on cost calculations for a non-contrast CT of the head versus an MRI of the brain with and without contrast).

The findings of this project are consistent with those from previous projects that implemented provider-targeted educational sessions based on national recommendations. For example, in 2017, Genies et al. developed an educational session for inpatient pediatric providers about the appropriate use of bronchodilators in patients with bronchiolitis and reported a 50% reduction in the rate of unnecessary prescribing of bronchodilators by the group (Genies et al., 2017). Additionally, Oliver et al. (2016) reported that a provider-directed educational session



based on the Choosing Wisely® recommendations for chest x-ray utilization reduced the number of unnecessary chest x-rays ordered for patients in the cardiovascular ICU (CVICU) by 17%. Their team organized an educational workshop with project champions and used scorecards to update providers on their chest x-ray use (Oliver et al., 2016). The collective findings from these quality improvement projects demonstrate the value of provider-directed educational sessions for decreasing the utilization of services that are not evidence-based.

While findings from the current project demonstrate the significant positive effects of provider-directed education, other strategies may also be considered when aiming to reduce unnecessary neuroimaging. For example, Rosenberg et al. (2015) evaluated seven of the Choosing Wisely® recommendations, including those for neuroimaging in uncomplicated headaches, and concluded that adhering to the guidelines led to a modest statistically significant improvement in the use of low-value services. They also advocated for considering provider feedback, educational interventions, and systems support when planning strategies to reduce unnecessary services further (Rosenberg et al., 2015). Thus, although the current study data indicate that a peer-to-peer, provider-directed educational session was successful in significantly decreasing unnecessary neuroimaging rates, it is possible that the rates could be further reduced by bundling strategies (e.g., adding clinical decision support tools).

Process quality improvement projects can improve adherence to national recommendations and enhance evidence-based practice, but how does appropriate utilization of services affect patient satisfaction? Several providers included in this project asked how they could address patients' requests for neuroimaging, suggesting that providers often have to make the difficult decision of whether to follow the clinical practice guidelines or satisfy patients (Hom, Ahuja, Smith, & Wintermark, 2016). Unfortunately, this is not a new theme. Given the

increasing nationwide attention to reducing unnecessary services the Institute for Clinical and Economic Review (ICER) recently evaluated the guidelines for improving neuroimaging utilization and acknowledged that when provider's bonuses are associated with patient satisfaction scores providers are placed in the difficult situation of weighing organizational metrics against evidence-based care (Reed & Pearson, 2015). If improved patient satisfaction scores are found to be associated with unnecessary neuroimaging, then it would be essential to develop standardized approaches for informing patients about the low value of neuroimaging for uncomplicated headache disorders and the potential adverse effects associated with unnecessary imaging.

### **Limitations**

There are limitations to this project. While nearly 2400 individual patient encounters for uncomplicated headache disorders occurred over the 16-week project interval, we could not adequately evaluate the sustainability of the reduced neuroimaging rates over such a short period. The impact of project participant behaviors were not measured and while the Hawthorne effect could play role in the improved neuroimaging rate this study was unable to measure it. As such, it is suggested that future projects assess unnecessary neuroimaging rates over a 6- to 12-month period to help determine the long-term impact of the educational session and if periodic provider-directed updates on the clinic's neuroimaging rate and the guidelines are needed to sustain best practices.

While providers included in this project offered the unsolicited feedback that they sometimes order neuroimaging because patients request the services or because they perceive that some patients need assurance that no life-threatening condition exists, providers were not explicitly asked why they initiate orders for unnecessary neuroimaging. A study in 2017 suggested that

past neuroimaging ordering patterns influence current and future ordering patterns (Hong et al., 2017). However, additional information is needed to determine more precisely why providers order unnecessary neuroimaging so that more tailored strategies can address the authentic needs of the providers. If ordering unnecessary neuroimaging is found actually to improve patient satisfaction scores then the value of patient satisfaction scores in bonus metrics should be re-evaluated because the goal of all performance metrics should be to provide high-quality evidence-based care.

Finally, this project was only conducted in the general neurology outpatient clinic. Although the majority of patients with headache disorders are evaluated in this clinic, some patients with headaches present to primary care clinics or the emergency department for treatment. Thus it may be beneficial to implement similar quality improvement projects in other departments to further reduce the use of unnecessary neuroimaging services across the organization.

### **Section VI: Conclusion**

As healthcare transitions from a fee-for-service model to a value-based-care model healthcare organizations face challenges. For example, continued overuse of low-value services such as neuroimaging for uncomplicated headaches reduces the quality of care and can lead to negative consequences for patients and organizations. The findings from the current quality improvement project indicate that a provider-directed educational session reviewing the evidence-based practice guidelines for neuroimaging was successful in significantly lowering the rate of unnecessary neuroimaging associated with uncomplicated headache diagnoses in a large urban outpatient neurology clinic. Providers are essential to successful quality improvement efforts; thus it is essential that healthcare organizations identify and address the needs of the providers. Provider-centered projects aim to empower one of the most vital healthcare

workforces with the information needed to adequately address the adverse political, ethical, and organizational outcomes low-value services such as unnecessary neuroimaging create.

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## Appendix A

### Synthesis Table

Citation	Conceptual framework	Design/ Methods	Sample	Major Variables	Outcome Measurement	Data Analysis	Findings	Level of Evidence	Quality of Evidence
1	Donabedian Model	Systematic Review	N/A	Creation of Quality Metrics	Decrease in Unnecessary neuroimaging	N/A	Neuroimaging generally not warranted	I	accepted in a QCDR
2	N/A	Literature Review	N/A	Low-value services create negative downstream effects	Do not utilize low-value services	N/A	Low-value services can cause financial and physical harm to patients	V	Valuable ethical insight
3	RAND/UCLA Appropriateness Method	Systematic review	N/A	Appropriateness of neuroimaging	Decrease in Unnecessary neuroimaging	N/A	Neuroimaging not warranted	I	CMS approved appropriateness use criteria
4	Logical Regression Model	quantitative study	US Healthcare providers	Can we predict ordering?	ordering of low-value services	multivariate-logistic model	Patterns can be established	VI	Quality evidence that supports why clinicians order tests.
5	N/A	Literature Review	N/A	How to reduce the cost of the headache evaluation	Decreased cost associated with headache evaluation	N/A	Neuroimaging not warranted	V	Methods were not defined and references were out of date
6	American Board of Internal Medicine Guidelines	Systematic review	N/A	Is neuroimaging needed and if so what type?	Decrease in Unnecessary neuroimaging	N/A	Neuroimaging not warranted	I	Quality evidence that supports reducing waste in healthcare
7	N/A	quantitative study	US Healthcare providers	Effects of Choosing Wisely	Are they effective?	Distributed stats P=0,05	Recommendations are effective	VI	Helps to understand what more is needed to reduce waste.

1. American Academy of Neurology. (2014). Headache Quality Measurement Set. [https://www.aan.com/uploadedFiles/Website\\_Library\\_Assets/Documents/3\\_Practice\\_Management/2\\_Quality\\_Improvement/1\\_Quality\\_Measures/1\\_All\\_Measures/2016\\_01\\_FINAL\\_AAN\\_Headache\\_Measurement\\_Set.pdf](https://www.aan.com/uploadedFiles/Website_Library_Assets/Documents/3_Practice_Management/2_Quality_Improvement/1_Quality_Measures/1_All_Measures/2016_01_FINAL_AAN_Headache_Measurement_Set.pdf)

2. Cote, D. J., & Laws, E. R. (2017). The Ethics of "Choosing Wisely": The Use of Neuroimaging for Uncomplicated Headache. *Neurosurgery*, 80(5), 816-819. doi:10.1093/neuros/nyw180

3. Douglas, A. C., Wippold 2nd, F. J., Broderick, D. F., Alken, A. H., Amin-Hanjani, S., Brown, D. C., . . . Zipfel, G. J. (2014). ACR Appropriateness Criteria Headache. *Journal of the American College of Radiology*, 11(7), 657-667. doi:10.1016/j.jacr.2014.03.024

4. Hong, A. S., Ross-Degnan, D., Fang, Z., Wharam, J. F., & Zhang, F. (2017). Clinician-Level Predictors for Ordering Low-Value Imaging. *JAMA Internal Medicine*, 177(11), 1577-1585. doi:10.1001/jamainternmed.2017.4888

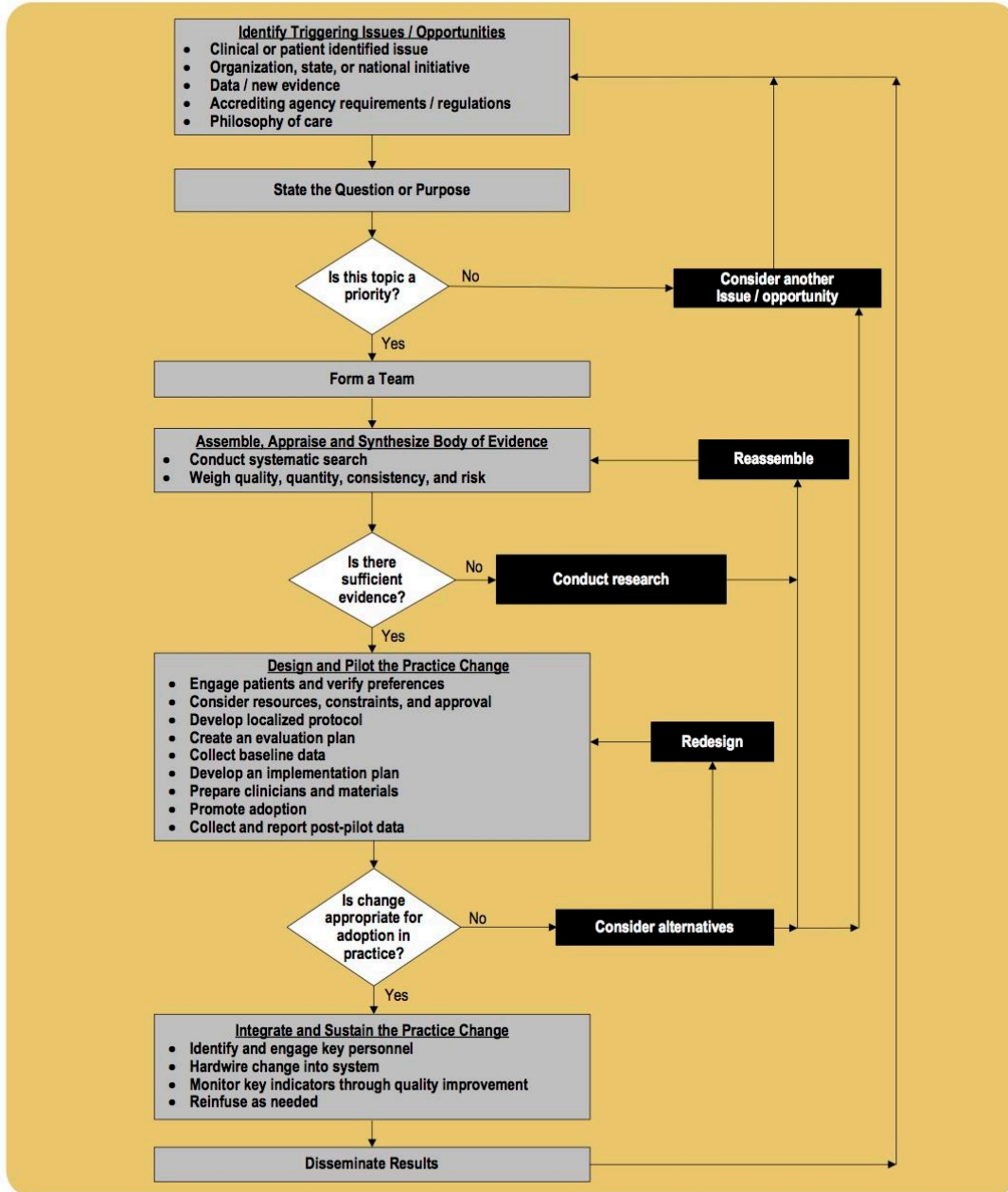
5. Katz, M. (2016). The Cost-Effective Evaluation of Uncomplicated Headache. *Medical Clinics of North America*, 100(5), 1009-1017. doi:10.1016/j.mcna.2016.04.009

6. Loder, E., Weizenbaum, E., Frisberg, B., Silberstein, S., & Force, A. H. S. C. W. T. (2013). Choosing wisely in headache medicine: the American Headache Society's list of five things physicians and patients should question. *Headache*, 53(10), 1651-1659. doi:10.1111/head.12233

7. Rosenberg, A., Agiro, A., Godlieb, M., Barron, J., Brady, P., Ying, L., . . . Liu, Y. (2015). Early Trends Among Seven Recommendations From the Choosing Wisely Campaign. *JAMA Internal Medicine*, 175(12), 1913-1920. doi:10.1001/jamainternmed.2015.5441

## Appendix B Iowa Model

### The Iowa Model Revised: Evidence-Based Practice to Promote Excellence in Health Care



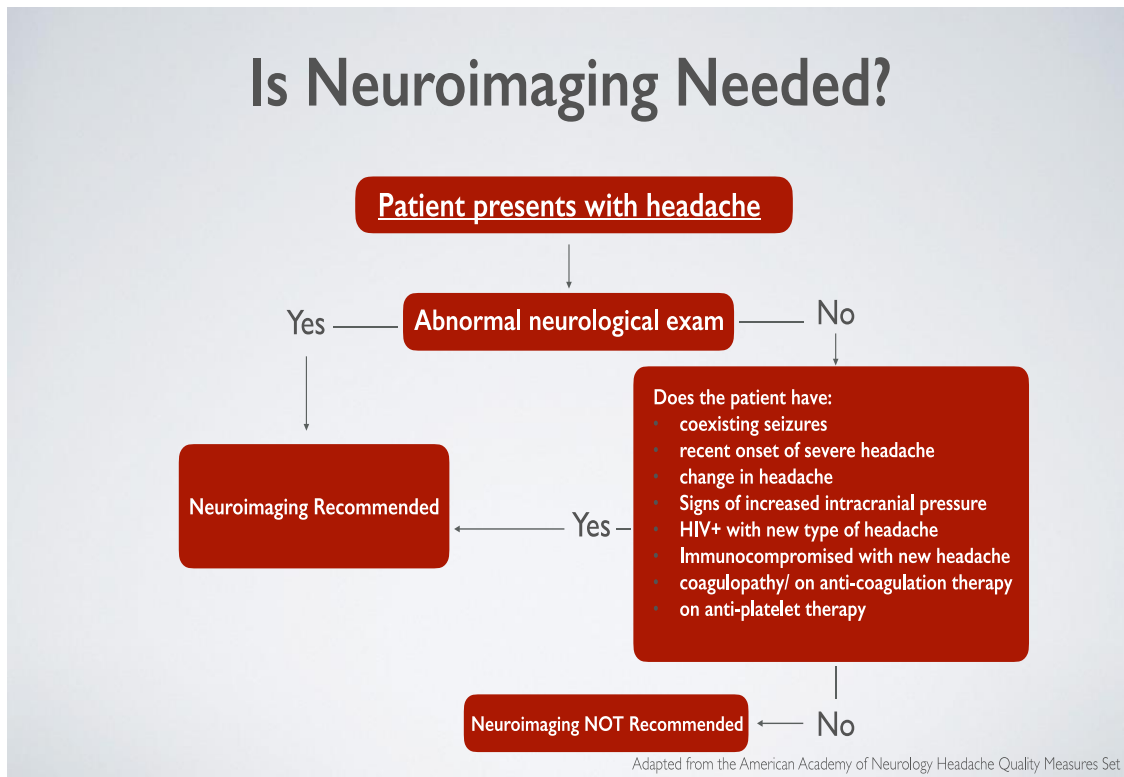
◆ = a decision point  
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## Appendix C Clinical Practice Guideline

CPG Neuroimaging	2	1
<p>Description of the Analytics Process</p>	<p>CINAHL (Cumulative Index to Nursing and Allied Health Literature), PubMed, Cochrane, and PsychINFO were searched for relevant literature on neuroimaging in primary headache syndromes by using two key words, “uncomplicated headache” and “imaging.” Inclusion criteria also included: “2012-2017,” “Peer-Reviewed,” “English,” and “human.” Twenty-six records were identified. Professional websites were examined for recommendations and three records were identified on the American Academy of Neurology (AAN) website and one record was identified through the Choosing Wisely site.</p> <p><b>Screening</b> Thirty records were screened. Four duplicate records were removed.</p> <p><b>Eligibility</b> 24 full-text records were assessed for eligibility using the rapid critical appraisal tool. Two multimedia records were assessed for eligibility. Eighteen records were excluded, as they did not correlate to the project PICOT question or, in the case of the multimedia records, a more complete record of the same information was identified.</p> <p><b>Included</b> Eight articles were included in the synthesis. All articles represented either systematic reviews, guidelines, or validated quality measures focused on decreasing low-value services such as neuroimaging in uncomplicated headache.</p>	
<p>Analysis of Evidence</p>	<p>Primary headache syndromes are debilitating for many patients, and, while benign, can be very concerning for patients and providers. Due to the benign nature of primary headache disorders, neuroimaging is generally not warranted, as it provides little to no patient benefit. The American Headache Society, AAN, and the American College of Radiology agree that neuroimaging is not indicated in patients with primary headache without symptoms suggestive of a secondary cause for the headache. The following could suggest a secondary cause of headache: an abnormal neurologic exam, seizures, change in previous headache, HIV positive patients with new headache, immunocompromised patients with new headache, patients with coagulopathies, on anticoagulation, or anti-platelet therapy, and patients with unexplained symptoms who are very young (American Academy of Neurology, 2014; Douglas et al., 2014; Loder, Weizenbaum, Frishberg, Silberstein, &amp; Force, 2013). If these signs and symptoms associated with secondary headache are identified in the patient presenting with headache neuroimaging should be ordered.</p>	
<p>ICD-10 Codes</p>	<p>ICD-10 Codes generally not warranting neuroimaging: G43.xxx, G44.xx, and R51</p>	
<p>Recommendations on Neuroimaging in Primary Headache Disorders</p>	<p><b>Strong Recommendation (against)</b></p>	

### Appendix D Neuroimaging Algorithm



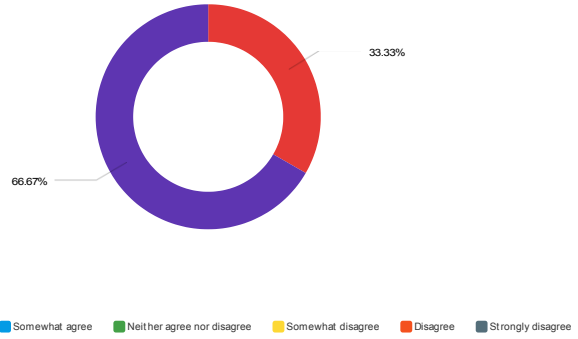
**Table 1**  
**Demographic Characteristics of Providers**

<b>Characteristic</b>	<b>Mean (SD)</b>	<b>n</b>	<b>Percent</b>
<b>Gender</b>			
Male		6	67
Female		3	33
<b>Education Level</b>			
Medical Degree		7	78
Master's Degree		2	22
<b>Time at Emory</b>			
(yrs.)	6.9 (4.5)		
0.3-5.0		4	44
5.0-10.0		2	22
> 10.0		3	33

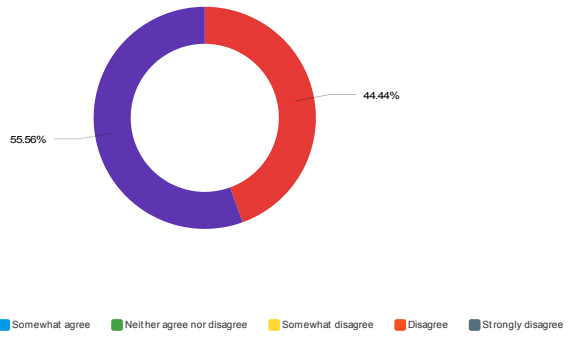
### Appendix E

#### Educational Session Evaluation

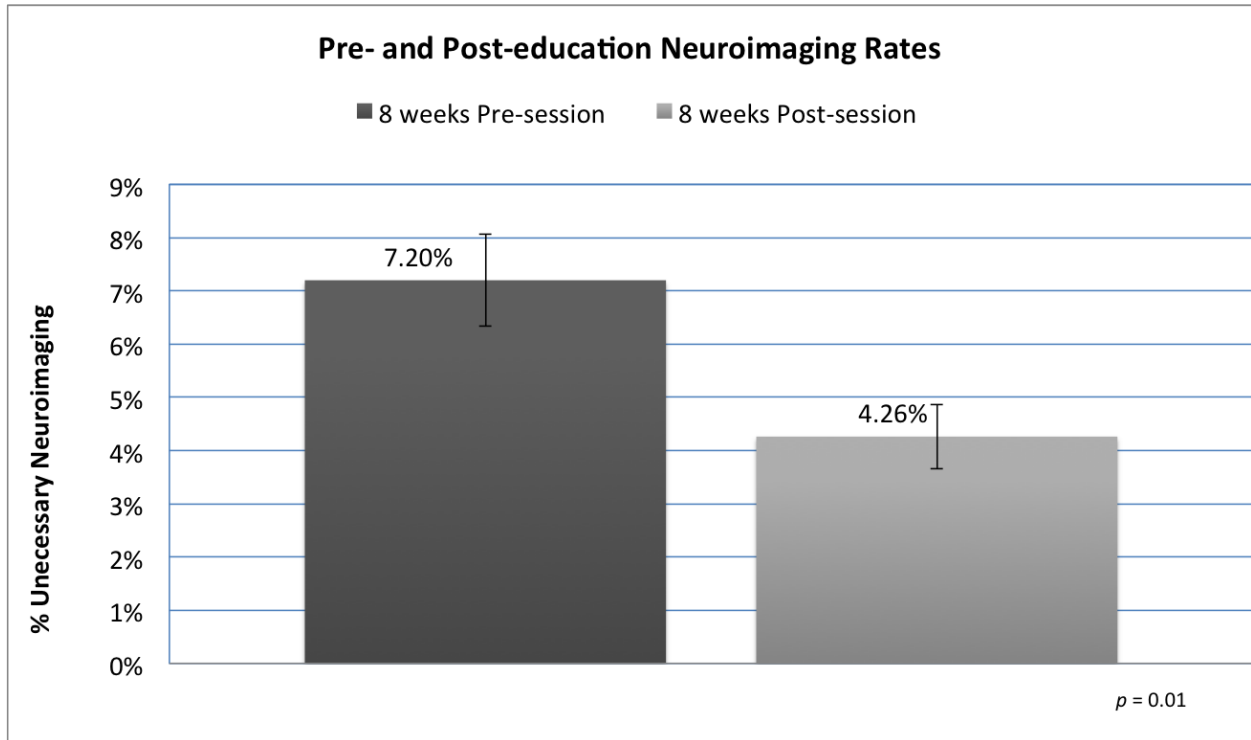
Did the structure and organization of the educational session meet your learning needs?



Did the instructor create an environment for learning through non-verbal and verbal communication?

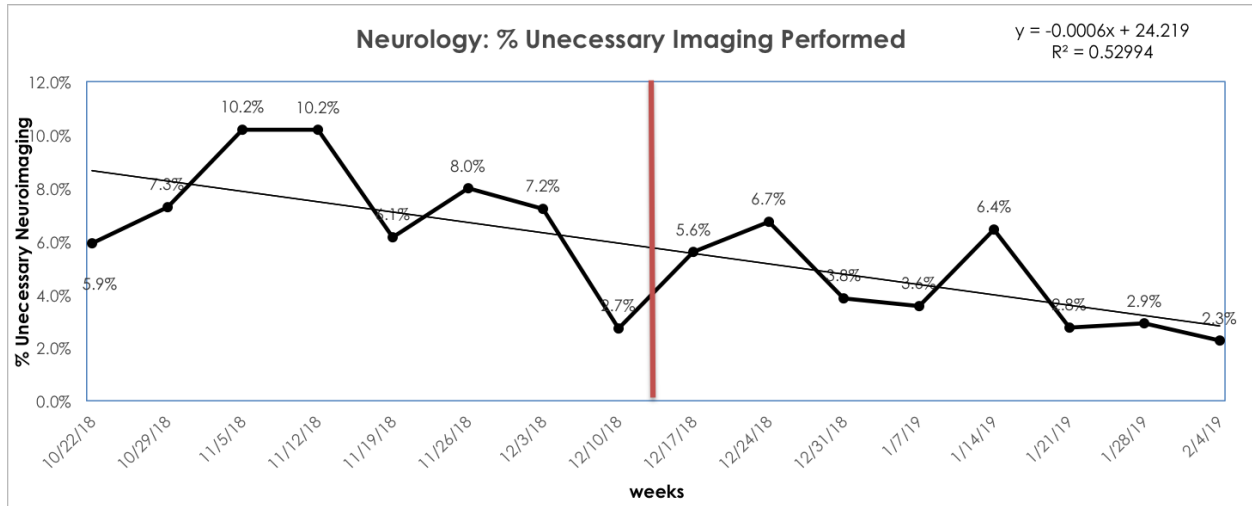


### Appendix F Pre and Post-education Neuroimaging Rates



This bar chart represents the change between the rate of unnecessary neuroimaging at 8-week intervals pre- and post-education.

### Appendix F % Unnecessary Neuroimaging over 16-weeks



This linear regression model represents the unnecessary neuroimaging rate in the neurology department over 16 weeks. The red bar represents when the provider-directed educational session took place.