MEASURE OVERVIEW

1. Measure Basic Information

Measure Title: Overuse of Imaging for the Evaluation of Children with Post-Traumatic Headache

Measure Citation Information: Macy ML, Freed GL, Reeves SL, Madden BW, McCormick J, Faasse T, Dombkowski KJ for the Quality Measurement Evaluation, Testing, Review, and Implementation Consortium. Overuse of imaging for the evaluation of children with post-traumatic headache. National Quality Measures Clearinghouse, Rockville (MD): Agency for Healthcare Research and Quality (AHRQ). Published July 4, 2016.

Measure Type: Process

Brief Description of the Measure: Percentage of children, ages 2 through 17 years old, with post-traumatic headache who were evaluated in the emergency department (ED) within 24 hours after an injury, and imaging of the head (computed tomography [CT] or magnetic resonance imaging [MRI]) was obtained in the absence of documented neurologic signs or symptoms that suggest intracranial hemorrhage or basilar skull fracture.

Subject/Topic Areas: Neurology: Brain injury

Cross Cutting Areas: Overuse, Safety

2. Specifications

Measure-Specific Webpage: http://www.chear.org/sites/default/files/stories/pdfs/img3_speconly.pdf

Data Dictionary Code Table or Value Sets: Attached at end of document. Data Code Tables provide lists of International Classification of Diseases, Ninth and Tenth Revisions, Clinical Modification (ICD-9-CM, ICD-10-CM) codes.

Numerator Statement: The number of numerator eligible children, ages 2 through 17 years old, with post-traumatic headache who were evaluated in the ED within 24 hours after an injury, and imaging of the head (CT or MRI) was obtained in the absence of documented neurologic signs or symptoms that suggest intracranial hemorrhage or basilar skull fracture.

Time Period for Data: The time period for data includes the measurement year (January 1 through December 31) (for imaging of the head for the evaluation of a post-traumatic headache) and the year (365 days) prior to the imaging event (for the purpose of identifying a claims-based denominator exclusion).

Numerator Details: Numerator exclusions are based on chart review; they are briefly summarized here and identified in the measure specification.

- Severe mechanism of injury (e.g., penetrating trauma, fall from more than 5 feet, struck by vehicle)
- History of seizure or convulsions associated with trauma
- History of loss of consciousness associated with trauma
- Repeated vomiting

- Documented basilar skull fracture or signs of suspected basilar skull fracture, including “Raccoon eyes,” Battle’s sign, and hemotympanum
- Abnormal neurologic examination or signs or symptoms of intracranial hemorrhage or increased intracranial pressure (e.g., decreased alertness, altered mental status, Glasgow Coma Scale Score <14, diplopia, abnormal face or eye movements, gait disturbance)

Denominator Statement: The number of children, ages 2 through 17 years old, with post-traumatic headache who were evaluated in the ED within 24 hours after an injury, and imaging of the head (CT or MRI) was obtained in the absence of suspected child abuse and neglect or a history of a medical condition that would otherwise warrant neuroimaging.

Target Population Category: Children's Health

Denominator Details: Eligible children must be ages 2 through 17 years old during the measurement year for which imaging of the head is obtained and must be continuously enrolled in their insurance plan during both the measurement year and the year prior. Eligible children must also receive head imaging in association with an ED visit for post-traumatic headache within 24 hours of the time of injury.

Denominator Exclusions: Children under evaluation for child abuse and neglect and children with a history of a medical condition that could otherwise warrant neuroimaging (e.g., bleeding disorder, intracranial tumor, hydrocephalus) for the evaluation of a post-traumatic headache were excluded from this overuse measure. Children with a diagnosis of headache without a documented history of trauma and children with a diagnosis of concussion without documentation of headache as a symptom were excluded because post-traumatic headache is the focus of this measure.

Denominator Exclusion Details: The complete list of ICD-9-CM code-based exclusions (with conversion to ICD-10-CM codes) that can be applied to administrative claims data are provided in the Data Code Table. Denominator exclusions are also applied to chart review and identified in the measure specification.

Type of Score: Rate/proportion

Interpretation of Score: Better quality = lower score

Calculation Algorithm/Measure Logic:

1. Identify children in the denominator:

    a. Using administrative claims, identify the population eligible for the denominator. The eligible population consists of all individuals who satisfy specified criteria, including age, enrollment, diagnosis, and imaging requirements within the measurement year.

    b. Using administrative claims, exclude individuals with ICD-9-CM codes/ICD-10-CM codes associated with child abuse and neglect or a history of a medical condition that could otherwise warrant neuroimaging for the evaluation of a post-traumatic headache.

    c. Select a random sample of those still eligible for the denominator for chart abstraction.

d. Among those who have a chart abstracted, exclude individuals with no documented time of injury or a time of injury greater than 24 hours prior to the ED visit, a diagnosis of headache without documentation of trauma, a diagnosis of concussion without documentation of headache as a symptom, concern for child abuse, or a history of a medical condition that could otherwise warrant neuroimaging to obtain the population included within the final denominator.

2. Identify children in the numerator:

   a. Among children included within the final denominator, exclude from the numerator individuals who have documented within the medical chart the following: severe mechanism of injury, seizure associated with trauma, loss of consciousness associated with trauma, repeated vomiting, documented or suspected basilar skull fracture, or abnormal neurologic examination including altered mental status, Glasgow Coma Scale score <14, abnormal face or extremity movements, or gait disturbance.

3. Calculate the percentage overuse (numerator / denominator times 100%).

Sampling: Administrative claims are used to identify the eligible population for the denominator and to identify claims-based denominator exclusions. From those still eligible for the denominator, a random sample is selected for chart abstraction. The final denominator population is determined using medical record data to identify remaining denominator exclusions. Medical record data are then used to identify numerator exclusions among children meeting eligibility for inclusion in the denominator.

Availability of medical records meeting inclusion criteria will vary by the entity using this measure. This measure was tested using a target sample of 200 abstracted charts for eligible children during the measurement year. Of the 204 charts abstracted for testing, 75 children had a headache diagnosis code and 67 of those charts were excluded because there was no clinical documentation of trauma occurring within 24 hours of the ED visit. Overall, we found 57 charts (27.9% of the sample obtained for chart review) met denominator criteria and were eligible for evaluation of measure numerator exclusions. A sample of 55 charts included in the denominator would yield a 95% confidence interval (CI) with a half-width of 8% for an expected overuse percentage of 10%. A sample size of 554 would be needed to achieve a 95% CI with a half-width of 2.5% for an expected overuse percentage of 10%. Larger numbers of abstracted charts will be required to ensure sufficient sample size; this will allow greater confidence in overuse percentage estimates and enable testing for differences between providers, hospital EDs, or health plans.

Data Source for which the Measure is Specified and Tested: Administrative claims, paper and electronic clinical data/paper and electronic health record

Data Source or Collection Instrument: Use of this measure requires administrative claims associated with ED visits during which neuroimaging was obtained for the evaluation of a child with post-traumatic headache. The clinical documentation from that ED visit, in paper or electronic medical record format, is required to determine if a case is eligible for inclusion in the measure denominator and numerator. Data could be obtained and analyzed at the hospital or health plan level.

Testing this measure using medical record data required the development of an abstraction tool and the use of qualified nurse abstractors. We provide an example data abstraction tool for chart review (see URL: http://www.chear.org/sites/default/files/stories/pdfs/img3_speconly.pdf).

Level of Analysis: Facility, Health Plan

Care Setting: Hospital/Acute Care Facility

3. Importance

See Evidence section for full details.

Opportunity for Improvement

Rationale for Measure: Post-traumatic headaches in children are a common clinical presentation in the setting of concussion and mild traumatic brain injury. In the United States, it has been estimated that more than 500,000 children younger than 15 years of age were evaluated in an ED following mild traumatic brain injury each year from 1998 to 2000 (Bazarian et al., 2005). Over the past decade, ED visits for traumatic brain injuries have increased substantially (Coronado et al., 2015).

Well-established evidence shows that neuroimaging to evaluate children with post-traumatic headache in the absence of documented neurologic signs or symptoms that suggest intracranial hemorrhage or skull fracture is rarely clinically indicated and is potentially harmful (Kuppermann et al., 2009; Lateef et al., 2009; Lateef et al., 2012; ACR Expert Panel on Pediatric Imaging, Ryan et al., 2014). The American Academy of Pediatrics Choosing Wisely initiative includes guidance to discourage the unnecessary use of CT scans for the immediate evaluation of minor head injuries and encourage reliance on clinical observation and criteria established by the Pediatric Emergency Care Applied Research Network (PECARN) to determine whether imaging is indicated (AAP Choosing Wisely, 2013; Kuppermann et al., 2009).

CT use has increased in the past 20 years. In a cross-sectional analysis of data from the National Hospital Ambulatory Medical Care Survey, Blackwell et al. (2007) found the use of CT scans for the evaluation of children with head injury nearly doubled from 1995 to 2003 (13% to 22%); Zonfrillo et al. (2015) found evidence to suggest continued increases in CT use for ED patients with concussion from 2006 to 2011. Some research suggests that rates of imaging following head injury appear to have declined in free-standing children's hospitals (Menoch et al., 2012; Mannix et al., 2012; Parker et al., 2015) and general EDs (Marin et al., 2014). Also, CT rates for children with mild head trauma vary widely between hospitals. CT rates ranged from 19% to 69% across 25 EDs (Stanley et al., 2014). Similarly, CT rates ranged from 19% to 58% for patients with minor head injury in a retrospective analysis of 5 years of hospital administrative data from 40 free-standing children's hospitals (Mannix et al., 2012).

Overuse has been defined as any patient who undergoes a procedure or test for an inappropriate indication (Lawson et al., 2012). Imaging overuse for the evaluation of children with post-traumatic headaches without signs or symptoms of intracranial injury subjects children to a number of risks (Malviya et al., 2000; Mathews et al., 2013; Pearce et al., 2012; Wachtel et al., 2009). Individuals who undergo CT scans in early childhood tend to be at greater risk for developing leukemia, primary brain tumors, and other malignancies later in life (Mathews et al., 2013; Pearce et al., 2012). Children are also at risk for complications from sedation or anesthesia, which are often required for longer CT imaging sequences and for MRI, and from intravenous contrast media (Zo'o et al., 2011). Cost is also an issue (Callaghan et al., 2014) that burdens the patient, as well as payers.

Citations:

American Academy of Pediatrics (AAP). Choosing Wisely: An initiative of the ABIM Foundation. Ten Things Physicians and Patients Should Question. 2013. Available at: http://www.choosingwisely.org/doctor-patient-lists/american-academy-of-pediatrics/; accessed: February 24, 2015.

American College of Radiology Expert Panel on Pediatric Imaging: Ryan ME, Palasis S, Saigal G, et al. ACR Appropriateness Criteria: Head trauma — Child. American College of Radiology, 2014. Available at: https://acsearch.acr.org/docs/3083021/Narrative/; accessed July 1, 2015.

Bazarian JJ, McClung J, Shah MN, Cheung YT, Flesher W, Kraus J. Mild traumatic brain injury in the United States, 1998-2000. Brain Inj 2005; 19(2):85-91.

Blackwell CD, Gorelick M, Holmes JF, Bandyopadhyay S, Kuppermann N. Pediatric head trauma: Changes in use of computed tomography in emergency departments in the United States over time. Ann Emerg Med 2007; 49(3):320-324.

Callaghan BC, Kerber KA, Pace RJ, Skolarus LE, Burke JF. Headaches and neuroimaging: High utilization and costs despite guidelines. JAMA Intern Med 2014; 174(5):819-821.

Coronado VG, Haileyesus T, Cheng TA, et al. Trends in sports- and recreation-related traumatic brain injuries treated in US emergency departments: The National Electronic Injury Surveillance System-All Injury Program (NEISS_AIP) 2001-2012. J Head Trauma Rehabil 2015; 30(3): 185-197.

Kuppermann N, Holmes JF, Dayan PS, et al., Identification of children at very low risk of clinically-important brain injuries after head trauma: A prospective cohort study. Lancet 2009; 374: 1160–1170.

Lateef TM, Grewal M, McClintock W, Chamberlain J, Kaulas H, Nelson KB. Headache in young children in the emergency department: Use of computed tomography. Pediatrics 2009; 124:1 e12-e17.

Lateef TM, Kriss R, Carpenter K, Nelson KB. Neurologic complaints in young children in the ED: When is cranial computed tomography helpful? Am J Emerg Med 2012; 30(8):1507-1514.

Lawson EH, Gibbons MM, Ko CY, Shekelle PG. The appropriateness method has acceptable reliability and validity for assessing overuse and underuse of surgical procedures. J Clin Epidemiol 2012; 65(11):1133-1143.

Malviya S, Voepel-Lewis T, Eldevik OP, Rockwell DT, Wong JH, Tait AR. Sedation and general anesthesia in children undergoing MRI and CT: Adverse events and outcomes. Br J Anaesth 2000; 84(6):743-748.

Mannix R, Meehan WP, Monuteaux MC, Bachur RG. Computed tomography for minor head injury: Variation and trends in major United States emergency departments. J Pediatr 2012; 160:136-139.

Marin JR, Weaver MD, Barnato AE, Yabes JG, Yealy DM, Roberts MS. Variation in emergency department head computed tomography use for pediatric head trauma. Acad Emerg Med 2014; 21(9):987-995.

Mathews JD, Forsythe AV, Brady Z, et al. Cancer risk in 680,000 people exposed to computed tomography scans in childhood or adolescence: Data linkage study of 11 million Australians. BMJ 2013; 346:f2360.

Menoch MJ, Hirsh DA, Khan NS, Simon HK, Sturm JJ. Trends in computed tomography utilization in the pediatric emergency department. Pediatrics 2012; 129(3):e690-e697.

Parker MW, Shah SS, Hall M, Fieldston ES, Coley BD, Morse RB. Computed tomography and shifts to alternate imaging modalities in hospitalized children. Pediatrics 2015; 136(3):e573-e581.

Pearce MS, Salotti JA, Little MP. et al. Radiation exposure from CT scans in childhood and subsequent risk of leukemia and brain tumours: A retrospective cohort study. Lancet 2012; 380(9840): 499–505.

Stanley RM, Hoyle JD Jr, Dayan PS, et al. Emergency department practice variation in computed tomography use for children with minor blunt head trauma. J Pediatr 2014; 165(6):1201-1206.

Wachtel RE, Dexter F, Dow AJ. Growth rates in pediatric diagnostic imaging and sedation. Anesth Analg 2009; 108(5):1616-1621.

Zonfrillo MR, Kim KH, Arbogast KB. Emergency department visits and head computed tomography utilization for concussion patients from 2006 to 2011. Acad Emerg Med 2015; 22(7):872-877.

Zo'o M, Hoermann M, Balassy C, et al. Renal safety in pediatric imaging: Randomized, double blind phase IV clinical trial of iobitridol 300 versus iodixanol 270 in multidetector CT. Pediatr Radiol 2011; 41(11); 1393-1400.

Performance Scores: We determined the neuroimaging overuse percentage among children evaluated with head CT or MRI in an ED for post-traumatic headache sampled from the HealthCore Integrated Research Database (HIRD). Of the 204 reviewed charts, 57 (27.9%) met denominator criteria: children, ages 2 through 17 years old, with post-traumatic headache who were evaluated in the ED within 24 hours after an injury, and imaging of the head (CT or MRI) was obtained. Among these, 15 children (26.3%) were imaged in the absence of documented neurologic signs or symptoms that suggest intracranial hemorrhage or skull fracture. Overall, our results indicate there is an opportunity to reduce the overuse of neuroimaging among children with post-traumatic headache. However, we were unable to assess plan, hospital ED, and provider level variations based on the limited number of eligible medical records that were available for calculation of this measure following chart review.

Disparities Data: Patient-level demographic and socioeconomic characteristics were generally unavailable from the medial records reviewed for measure testing. Therefore, we used ZIP-code level race and ethnicity, median household income, and urbanicity, collected for the 2010 United States Census and the 2011 American Community Survey (ACS), as proxy variables to characterize the population. The small numbers of eligible numerator and denominator cases (n=15 and n=57, respectively) do not allow for meaningful comparisons of overuse of neuroimaging among children with post-traumatic headache evaluated in EDs across different socio-demographic groups.

Race and Ethnicity - Census Characteristics

On average, children with post-traumatic headache who obtained neuroimaging resided in ZIP codes reporting primarily white race (80.2%) and modest levels of Hispanic ethnicity (9.8%). The children included in the denominator group resided in ZIP codes reporting a higher proportion of white residents (81.8%) and a similar proportion of Hispanic ethnicity (10.0%). The children included in the numerator group resided in ZIP codes reporting a still higher proportion of white residents (83.3%) and a slightly lower proportion of residents of Hispanic ethnicity (6.5%). These demographic characteristics differ from the population of the United States as a whole, as the 2010 US Census data indicates that approximately 72.4% of the population was white, 13.2% of the population was black, and 16.3% of the population was of Hispanic ethnicity in 2010. The summary statistics for race and ethnicity within ZIP code across the sampled subgroups of children with valid ZIP codes are reported in the Testing section of this document - Tables 1 and 2.

Socioeconomic Status – Census Characteristics

On average, the ZIP code-level median household income for children with post-traumatic headache who obtained neuroimaging was $69,540. The children in the denominator group resided in ZIP codes with higher median household incomes (mean $81,430) and those included in the numerator group resided in ZIP codes with lower median household incomes (mean $65,263). The median household income for the ZIP-codes in which these children resided was substantially higher than the median household income of the population of the entire United States as reported in the ACS in 2011, which is $50,502. The summary statistics for distribution of the ZIP-code level median household income for sampled groups of children with valid ZIP codes and complete census data are reported in the Testing section of this document -Table 3.

Urbanicity – Census Characteristics

Children with post-traumatic headache who obtained neuroimaging primarily reside in urban ZIP codes (75.4%). The subset of children meeting denominator criteria resided in ZIP codes that were slightly more urban (77.9%), and those children meeting numerator criteria resided in less urban ZIP codes (66.6%). The proportion of children in this sample who resided in urban ZIP codes is similar to the rest of the United States, where approximately 79% of the population resides in an urban area. The summary statistics for urbanicity within ZIP code for sampled groups of children with valid ZIP codes are reported in the Testing section of this document- Table 4.

Summary of Disparities Data from the Literature: In a cross-sectional study of 50,835 pediatric emergency visits for head injury captured in the National Hospital Ambulatory Medical Care Survey 2002-2006, white race was associated with higher odds of neuroimaging (OR 1.5, 95% CI: 1.02-2.1) (Mannix et al., 2010). Natale and colleagues (2012) conducted a secondary analysis of data prospectively collected for PECARN head imaging decision rule (Kuppermann et al., 2009) to test for associations between race/ethnicity and the ordering of CT among children with blunt head injury. They found that children of black non-Hispanic or Hispanic race/ethnicity had lower odds of undergoing head CT than white non-Hispanic children. Parental anxiety and parental request were cited as reasons for ordering head CT in children of white, non-Hispanic race/ethnicity. Their findings suggest that overuse of CT imaging may disproportionately affect white, non-Hispanic children. Similarly, Morrison and colleagues (2015) found that minority race was associated with less radiologic testing in the children of parents with low health literacy in a cross-sectional study of 504 caregivers accompanying their child to a pediatric ED. When associated with race/ethnicity, overuse of health care, in general, is greater among white patients (Kressin and Groeneveld, 2015).

Citations:

Kressin NR, Groeneveld PW. Race/ethnicity and overuse of care: A systematic review. Milbank Q 2015; 93(1):112-138.

Kuppermann N, Holmes JF, Dayan PS, et al. Identification of children at very low risk of clinically-important brain injuries after head trauma: A prospective cohort study. Lancet 2009; 374: 1160–1170.

Mannix R, Bourgeois FT, Schutzman SA, Bernstein A, Lee LK. Neuroimaging for pediatric head trauma: Do patient and hospital characteristics influence who gets imaged? Acad Emerg Med 2010; 17(7):694-700.

Morrison AK, Brousseau DC, Brazauskas R, Levas MN. Health literacy affects likelihood of radiology testing in the pediatric emergency department. J Pediatr 2015; 166(4):1037-1041.

Natale JE, Joseph JG, Rogers AJ, et al. Cranial computed tomography use among children with minor blunt head trauma. Association with race/ethnicity. Arch Pediatr Adolesc Med 2012; 166(8):732-737.

High Priority

Demonstrated high priority aspect of health care: Affects large numbers, frequently performed procedure, high resource use, patient/societal consequences of poor quality

4. Scientific Acceptability

See Testing section for full details.

5. Feasibility

Data Sources

How Are the Data Elements Needed to Compute Measure Scores Generated?

- Generated or collected by and used by health care personnel during the provision of care (e.g., blood pressure, lab value, diagnosis, depression score)
- Coded by someone other than person obtaining original information (e.g., DRG, I CD-9 codes on claims)
- Abstracted from a record by someone other than person obtaining original information (e.g., chart abstraction for quality measure or registry)

Electronic Sources: Some data elements are in defined fields in electronic sources

Near-Term Path to Electronic Capture/Rationale for Using Other than Electronic Sources: Our results indicate that the data elements required for the calculation of this measure are typically recorded in electronic health record (EHR) systems. However, important information required for numerator or denominator exclusion criteria may be recorded in an unstructured format in problem lists, as well as in nursing and physician notes. Order entry systems can provide structured information about orders placed for neuroimaging studies; this furnishes key information necessary for future applications of the measure. Importantly, for this measure to be accurate, it may be necessary to combine data from multiple EHR systems. The use of Health Information Exchange (HIE), especially using the DIRECT protocol for exchange across individual electronic medical records (EMRs), would be an important tactical step to enable this measure.

Data Collection Strategy

Lessons Learned: This measure was tested using medical record data after administrative claims were used to identify the population to sample for chart review. Administrative data needed for this measure include date of birth, diagnosis codes, and procedure codes and dates. These data are generally available, although obtaining them may require a restricted-use data agreement and Institutional Review Board (IRB) approval.

Testing this measure using medical record data required the development of an abstraction tool and the use of qualified nurse abstractors. We provide an example data abstraction tool for chart review. Review of clinical documentation was required to ensure that exclusions were appropriately captured for the determination of overuse of neuroimaging (i.e., imaging obtained in the absence of indicators of intracranial hemorrhage or basilar skull fracture).

Our review of medical charts indicated that 72.1% (147/204) of the children who were included in the chart review sampling population after the application of administrative claims exclusions were subsequently excluded from the denominator based on information in the medical chart. Importantly, the majority of numerator exclusions (i.e., symptoms of intracranial injury that represent a clinical indication for neuroimaging) were not adequately captured in administrative claims. As a consequence, using administrative data alone would result in a substantial overestimation of the degree to which neuroimaging is overused in the evaluation of children with post-traumatic headache. This finding is not unexpected, as there are several exclusions that can only be accurately captured through review of clinical documentation contained within the medical record. As an example, one denominator exclusion criterion, time of injury greater than 24 hours, cannot be identified through the use of administrative claims.

Chart review also may be beneficial to confirm that individuals with claims-based denominator exclusions have been appropriately identified and removed from the final eligible population, although we found high validity between data elements available within administrative claims compared with data elements documented within the medical chart (see Testing section). Additionally, chart review is necessary to determine that cases meet measure inclusion criteria for post-traumatic headache. Some of the ICD-9-CM codes used to identify cases for chart review were intentionally non-specific, such as ‘general symptoms of headache’ (ICD-9-CM code 784.0), as they reflect codes that are used in clinical practice to bill for care delivered to children with post-traumatic headache but require determination of a trauma history within 24 hours of the ED visit based on chart review.

This measure was tested using a target sample of 200 abstracted charts for eligible children during the measurement year. The yield of charts eligible after the application of denominator exclusions was lower than expected; 27.9% of the 204 charts abstracted for testing were eligible for the denominator. In addition, 67 of the 75 children had a ‘general symptoms of headache’ diagnosis code and had no clinical documentation of trauma occurring within 24 hours of the ED visit. The inclusion of this non-specific code contributed substantially to the attrition of eligible cases. Larger samples of charts would be required for abstraction in order to ensure adequate sample size remains in the denominator after application of exclusion criteria. To detect differences between two health plans, hospital EDs, or providers with overuse percentages of 20% and 10%, would require a sample size of at least 199 denominator-eligible cases per group, with a p-value of 0.05 and 80% power.

Continuing advances in the development and implementation of EHRs may prompt providers to document key elements needed for application of inclusion and exclusion criteria necessary for this measure. Advances would further allow for electronic capture of structured clinical information needed to determine if and when neuroimaging has been overused in the evaluation of children experiencing a post-traumatic headache.

6. Usability and Use

Planned Use: Public reporting, payment program, quality improvement with external benchmarking to multiple organizations

Reasons for Lack of Current Use: This measure provides families, purchasers, providers, and policy makers with a straightforward means to assess any potential overuse of imaging in the ED involving the care of children with post-traumatic headache. The primary information needed for this measure comes from administrative claims and medical record data and includes basic demographics, diagnostic codes, procedure codes, and times of services, all of which are widely available.

The only issue impeding broad use is dissemination of the measure.

Implementation Plan: Year 1-2: Dissemination of measure specifications to targeted certifying/regulatory organizations (e.g., Joint Commission), health plans, hospital groups, professional organizations (i.e., Children’s Hospital Association), payers, CMS and other government agencies, and health care institutions (hospitals, urgent care centers).

Year 2-3: Public reporting of initial data collected from measure use across hospitals. This may occur in a number of ways: (1) via a collaborative approach with a group of hospitals through an organization such as the Children’s Hospital Association, (2) assessment of data from Medicaid claims, (3) data aggregation from payers regarding their enrolled patients, or (4) data aggregation across hospital groups that implement the measure (e.g., Tenet).

Year 3: Refinement and review of updated literature available following initial publication of the measure. Re-calibration of the measure based on updated specifications and initial data from use.

Year 4-5: Re-introduction and ongoing testing of measure.

Year 6: Refinement and review of updated literature available following initial publication of the measure. Public reporting of measure performance at the level of the health care facility.

Unintended Negative Consequences: No unintended negative consequences to individuals or populations were identified during testing. The primary potential unintended consequence of a quality measure to assess the extent to which imaging is overused would be reduction of imaging for children who do have an indication. In other words, the measurement of overuse could result in underuse. By measuring overuse (imaging *without the appropriate indications*) and not use (imaging for any indication), we have specified the situations where reduction in imaging would be of greatest benefit.

7. Related and Competing Measures

This pediatric measure is aligned with NQF Measure number 0668: Appropriate Head CT Imaging in Adults with Mild Traumatic Brain Injury. The measures are harmonized in terms of the basic clinical criteria (imaging obtained in the ED within 24 hours of a head injury among patients with a Glasgow Coma Scale score of greater than or equal to 14) used to identify the population eligible for inclusion in the denominator. The pediatric measure differs in several ways, including consideration of current trends in neuroimaging, the ability to use administrative claims to narrow the population considered eligible for the more labor intensive chart review process, and the available evidence on the need for neuroimaging of children with post-traumatic headache. The endorsed adult measure is focused on CT imaging alone; this pediatric measure was tested to assess the overuse of neuroimaging more broadly, including both CT and MRI, for children who are evaluated for post-traumatic headache. The inclusion of MRI is important with recent shifts toward imaging modalities that avoid radiation exposure but still subject patients to risks from sedation/anesthesia, incidental findings, and costs associated with overuse of imaging studies. The pediatric measure was tested in a two-stage approach that first used administrative claims to identify the potentially eligible population and then used chart review in order to account for exclusions that could be documented in the provider notes but not captured with a relevant ICD-9-CM code. We included an extensive list of ICD-9-CM codes indicative of conditions in which neuroimaging for post-traumatic headache could be warranted (for example, coagulopathy or cerebral cyst) in order to focus this measure on clear cases of overuse of neuroimaging. Finally, we applied the specific factors that were identified by Kuppermann and colleagues as relevant to the risk of clinically important brain injury in children with minor trauma based on results of the largest prospective cohort study of pediatric traumatic brain injury.

There is overlap between the NQF Measure number 0668: Appropriate Head CT Imaging in Adults with Mild Traumatic Brain Injury and the pediatric measure. The adult measure includes children 16 to 18 years old, while the pediatric measure is more narrowly focused on children 2 through 17 years of age. Because of the unique nature of child illness and injury, a pediatric-focused measure is needed.

8. Additional Information

Measure Developer: QMETRIC, Gary Freed, MD, MPH, principal investigator, University of Michigan; gfreed@med.umich.edu, (734) 232-0657

Workgroup/Expert Panel Involved in Measure Development: The face validity of this measure was established by a national panel of experts and parent representatives for families of children with headaches and seizures convened by Q-METRIC. The Q-METRIC Representative Panel included nationally recognized experts in the area of imaging children, representing general pediatrics, pediatric radiology, pediatric neurology, pediatric neurosurgery, pediatric emergency medicine, general emergency medicine, and family medicine. The Q-METRIC Feasibility Panel included experts in state Medicaid program operations, health plan quality measurement, health informatics, and health care quality measurement. In total, the Q-METRIC imaging panel included 15 experts, providing a comprehensive perspective on imaging children and the measurement of quality metrics for states and health plans.

The Q-METRIC expert panels concluded that this measure has a high degree of face validity through a detailed review of concepts and metrics considered to be essential to appropriately imaging children. Concepts and draft measures were rated by this group for their relative importance. This measure was highly rated, receiving an average score of 7.0 (with 9 as the highest possible score).

Representative Panel

Dana Cook, Parent Representative, Paw Paw, MI

Peter Dayan, MD, MSc, Division of Pediatric Emergency Medicine, Morgan Stanley Children's Hospital, New York, NY

Lisa Dover, Parent Representative, Ann Arbor, MI

Danny Greig, MD, FAAFP, Emergency Room Physician, MidMichigan Medical Center, Midland, MI

Blaise Jones, MD, Director of Clinical Services, Chief of Neuroradiology, Cincinnati Children's Hospital Medical Center, Cincinnati, OH

Steven Leber, MD, PhD, Professor of Pediatrics and Neurology, University of Michigan, Ann Arbor, MI

Cormac Maher, MD, Associate Professor of Neurosurgery, University of Michigan, Ann Arbor, MI

L. Kendall Webb, MD, Assistant Professor of Emergency Medicine, Director of IT for the Emergency Department, University of Florida, Jacksonville, Jacksonville, FL

Neal Weinberg, MD, FAAP, General Pediatrician, IHA Pediatric Healthcare – Arbor Park, Ann Arbor, MI

Feasibility Panel

Cathy Call, RN, BSN, MSEd, MSN, CPHQ, PMP, LSS, Practice Area Leader for Health Quality Research, Health Care Analytics Group, Altarum Institute, Alexandria, VA

Andrea DeVries, PhD, Director of Research Operations, HealthCore Inc., Wilmington, DE

J. Mitchell Harris, PhD, Director of Research and Statistics, Children’s Hospital Association, Alexandria, VA

Don Lighter, MD, MBA, Director, The Institute for Health Quality Research & Education, Knoxville, TN

Sue Moran, BSN, MPH, Director of the Bureau of Medicaid Program Operations and Quality

Assurance, Michigan Department of Community Health, Lansing, MI

Stuart Weinberg, MD, Assistant Professor of Biomedical Informatics, Assistant Professor of Pediatrics, Vanderbilt University, Nashville, TN

Q-METRIC Investigators

Michelle L. Macy, MD, MS, Assistant Professor, Departments of Emergency Medicine and Pediatrics, School of Medicine, University of Michigan, Ann Arbor, MI

Gary L. Freed, MD, MPH, Professor of Pediatrics, School of Medicine and Professor of Health Management and Policy, School of Public Health, University of Michigan, Ann Arbor, MI (principal investigator)

Kevin J. Dombkowski, DrPH, MS, Research Associate Professor of Pediatrics, School of Medicine, University of Michigan, Ann Arbor, MI

Funding: This work was funded by the Agency for Healthcare Research and Quality (AHRQ) and the Centers for Medicare & Medicaid Services (CMS) under the CHIPRA Pediatric Quality Measures Program Centers of Excellence grant number U18 HS020516. AHRQ, in accordance to CHIPRA 42 U.S.C. Section 1139A(b), and consistent with AHRQ's mandate to disseminate research results, 42 U.S.C. Section 299c-3, has a worldwide irrevocable license to use and permit others to use products and materials from the grant for government purposes, which may include making the materials available for verification or replication by other researchers and making them available to the health care community and the public, if such distribution would significantly increase access to a product and thereby produce substantial or valuable public health benefits.

Gary L. Freed, MD, MPH
Percy and Mary Murphy Professor of Pediatrics, School of Medicine
Professor of Health Management and Policy, School of Public Health
Principal Investigator, Q-METRIC
Child Health and Evaluation Research (CHEAR) Unit

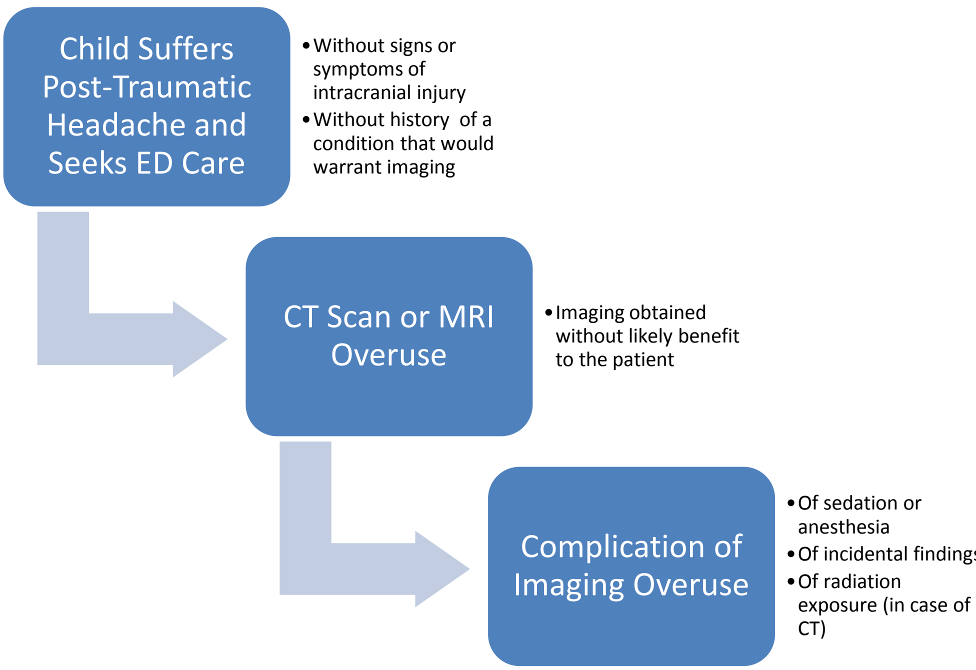
Division of General Pediatrics
University of Michigan Hospital and Health Systems
Ann Arbor, MI 48109-5456

MEASURE EVIDENCE

Measure Title: Overuse of Imaging for the Evaluation of Children with Post-Traumatic Headache

Measure Type: Process. Imaging (CT or MRI) of children with post-traumatic headache who are evaluated in the emergency department (ED) within 24 hours after an injury, in the absence of documented neurologic signs or symptoms that suggest intracranial hemorrhage or skull fracture.

Steps: Illustrate path between structure, process, intermediate outcome, and health outcomes, including all the steps between the measure focus and the health outcome.



CT and MRI of the brain are the neuroimaging modalities at the center of this overuse measure. Both are radiologic modalities used to create images of internal structures in a slice-by-slice manner. CT uses X-ray radiation (hereafter simply called radiation), and MRI uses magnetic fields and radio waves.

Currently, professional guidelines do not support neuroimaging in children 2 years and older with minor head injury in the absence of neurologic signs or high risk factors indicative of intracranial injury (ACR Expert Panel on Pediatric Imaging, Ryan et al., 2014). Potential consequences of imaging overuse include complications of sedation or anesthesia, incidental findings, and radiation exposure. Therefore, measurement of overuse of neuroimaging with CT and MRI is an important quality indicator among children with post-traumatic headache following minor head injury.

1. Body of Evidence Supporting the Measure

Source of Systematic Evidence Review Supporting the Measure: Clinical Practice Guideline recommendation.

American College of Radiology Expert Panel on Pediatric Imaging: Ryan ME, Palasis S, Saigal G, et al. ACR Appropriateness Criteria: Head Trauma — Child. American College of Radiology, 2014. URL: https://acsearch.acr.org/docs/3083021/Narrative/.

Specific Guideline Recommendation: The American College of Radiology (ACR) Appropriateness Criteria® (AC) are evidence-based guidelines to assist referring physicians and other providers in making the most appropriate imaging or treatment decision for a specific clinical condition. The AC assess the benefits and harms of recommended medical care or advanced diagnostic imaging options, using scientific evidence, to the extent possible, and clinical judgment and expert consensus, as necessary. The guidelines are developed by experts in diagnostic imaging, interventional radiology, and radiation oncology with participation from over 20 medical societies.

American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Head Trauma — Child**

Variant 1: **Minor head injury (GCS >13) ≥2 years of age without neurologic signs or high risk factors (eg, altered mental status, clinical evidence of basilar skull fracture). Excluding nonaccidental trauma.**

Radiologic Procedure	Rating	Comments	RRL*
CT head without contrast	3	This is a known low-yield procedure.	☢☢☢
MRI head without contrast	2		O
X-ray head	1		☢
CT head without and with contrast	1		☢☢☢☢
CT head with contrast	1		☢☢☢
CTA head with contrast	1		☢☢☢☢
MRI head without and with contrast	1		O
MRA head without contrast	1		O
MRA head without and with contrast	1		O
Arteriography cerebral	1		☢☢☢☢
US head	1		O
FDG-PET/CT head	1		☢☢☢☢
Tc-99m HMPAO SPECT head	1		☢☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢☢	0.1-1 mSv	0.03-0.3 mSv
☢☢☢	1-10 mSv	0.3-3 mSv
☢☢☢☢	10-30 mSv	3-10 mSv
☢☢☢☢☢	30-100 mSv	10-30 mSv

*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies".

Note: These tables are reproduced from pages 1 and 10 of the American College of Radiology (ACR) Expert Panel on Pediatric Imaging: Ryan ME, Palasis S, Saigal G, et al. ACR Appropriateness Criteria: Head Trauma — Child. American College of Radiology, 2014. Available at: https://acsearch.acr.org/docs/3083021/Narrative/ ; accessed June 30, 2015.

Recommendation Grade: CT scans and MRI of the head in children older than 2 years with minor head injury and without neurologic signs or high risk factors has been rated Category 3 or lower for appropriateness. Categories 1, 2 and 3 are considered "usually not appropriate," where the harms of the procedure outweigh the benefits.

Citation for Methodology for Grading Recommendations: The ACR panel members rate appropriateness based on the RAND Appropriateness Method (Fitch K. The Rand/UCLA appropriateness method user's manual. Santa Monica: Rand; 2001). URL: http://www.rand.org/content/dam/rand/pubs/monograph_reports/2011/MR1269.pdf

Each panel member assigns a rating; these are then presented to the group with the frequency distribution and the median group rating. Final ratings are determined using a modified Delphi method.

Specific Element Addressed in the Evidence Review: The specific service addressed was imaging of children with head trauma. The body of evidence summarized in these responses is from the American College of Radiology Expert Panel on Pediatric Imaging: Ryan ME, Palasis S, Saigal G, et al. ACR Appropriateness Criteria: Head Trauma — Child. American College of Radiology, 2014. https://acsearch.acr.org/docs/3083021/Narrative/; accessed July 1, 2015. Evidence Table URL: http://www.acr.org/~/media/6F3EEA65C42E47E7BCC529CDDCC77DB7.pdf

Grade Assigned for the Quality of the Evidence: ACR staff determine if the following study quality elements are described in each article included in the evidence tables that are presented with the Appropriateness Criteria:

- Uncertainty measure
- Prospective study
- Systematic recruitment or recruitment of a consecutive series of patients
- Standard of reference or comparison of two imaging tests
- Reference standard applied
- Independent readers of the imaging test
- Index test results interpreted in a blinded fashion

The staff then counts the number of quality elements recorded as present in each article and assigns a Study Quality Category from 1 to 4. Category 1 (well-designed study that accounts for common biases) must have all eight study quality elements present; Category 2 (moderately well-designed study that accounts for most common biases) has six to seven quality elements present; Category 3 (study that has important design limitations) has three, four or five quality elements present, and Category 4 (not useful as primary evidence, may not be a clinical study or the study design is invalid, or conclusions are based on expert consensus) has two or fewer quality elements present.

Time Period Covered: 1984-2013

<u>2. Quantity and Quality of Body of Evidence</u>

Number and Type of Study Designs included in the Body of Evidence:

- 47 Review/Other-Diagnostic Studies
- 21 Observational-Diagnostic Studies

Overall Quality of Evidence across Studies in the Body of Evidence: Of the 68 studies referenced in the evidence table, the assigned evidence quality grades range from Category 2 to Category 4. No studies were rated as Category 1; five studies were rated as Category 2 (three related to decision rules for imaging children with minor trauma, one related to severe head injury, and one related to imaging modalities for the evaluation of head injury); 14 studies were rated as Category 3 (eight related to epidemiology of head injury and imaging decision rules); and 49 studies were rated as Category 4.

The evidence supports that CT is the primary imaging modality for children with acute traumatic brain injury and is overused for the evaluation of children. Numerous clinical decision rules have been put forth to reduce neuroimaging in children who have a low likelihood of intracranial injury requiring intervention.

The Pediatric Emergency Care Applied Research Network (PECARN) conducted the largest prospective study of children presenting to the ED within 24 hours of head injury and confirmed numerous prior lower quality studies that had documented low yield of neuroimaging of children with head injuries in the absence of signs or symptoms to suggest intracranial injury, as summarized in the Evidence Table published by the ACR Expert Panel on Pediatric Imaging, Head Trauma — Child (Ryan et al., 2014).

The PECARN head imaging clinical decision rule for children with mild traumatic brain injury has 99.9% negative predictive value and 96.8% sensitivity for predicting clinically important injury. The PECARN study provides evidence that imaging was overused in approximately 20% of the study population 2 years and older who demonstrated none of the six predictors comprising the decision rule.

3. Estimates of Benefit and Consistency across Studies in Body of Evidence

Estimates of Benefit across Studies: The main benefit of reducing neuroimaging among children with post-traumatic headache relates to the avoidance of harms. Schachar et al. (2011) tested the sensitivity and specificity of three clinical decision rules (New Orleans Criteria, Canadian CT Head Rule, and NEXUS II) in a population of 2,101 children with head injuries. The authors found sensitivities ranging from 65.2% (95% CI 69.9-86.7) for the Canadian CT Head Rule to 96.7% (95%CI: 93.1-100) for the New Orleans Criteria and negative predictive values above 97%. Specificity ranged from 11.2% (95% CI: 9.8-12.6) for the New Orleans Criteria to 64.2% for the Canadian CT Head Rule.

The evidence related to the need for neuroimaging in the evaluation of children within 24 hours of mild traumatic brain injury was greatly strengthened by research conducted by PECARN investigators. Their research found that CT scans were obtained for 14,969 (35%) of 42,412 children evaluated in participating EDs within 24 hours of head injury; however, clinically important traumatic brain injuries were present in just 376 (<1%) (Kuppermann et al., 2009). This study generated a clinical decision rule that can guide the decision to order CT imaging for children with mild head trauma and no findings that suggest clinically important traumatic brain injury.

The PECARN head imaging clinical decision rule for children with mild traumatic brain injury has 99.9% negative predictive value and 96.8% sensitivity for predicting clinically important injury. The PECARN study provides evidence that imaging was overused in approximately 20% of the study population 2 years and older who demonstrated none of the six predictors comprising the decision rule.

Citations:

Kuppermann N, Holmes JF, Dayan PS, et al., Identification of children at very low risk of clinically-important brain injuries after head trauma: A prospective cohort study. Lancet 2009; 374: 1160–1170.

Schachar JL, Zampolin RL, Miller TS, Farinhas JM, Freeman K, Taragin BH. External validation of the New Orleans Criteria (NOC), the Canadian CT Head Rule (CCHR) and the National Emergency X-Radiography Utilization Study II (NEXUS II) for CT scanning in pediatric patients with minor head injury in a non-trauma center. Pediatr Radiol 2011; 41(8):971-979.

Harms Studied and their Effect on Net Benefit: CT use has increased in the past 20 years without an increase in the yield of imaging studies. CT rates for children with mild head trauma vary widely between hospitals. CT rates ranged from 19% to 58% for patients with minor head injury in a retrospective analysis of 5 years of hospital administrative data from 40 free-standing children's hospitals (Mannix et al., 2012). This research also suggests that rates of imaging following head injury may be declining in free-standing children's hospitals in recent years.

The harms of neuroimaging among children with post-traumatic headache have not been directly studied but can be implied from the literature that describes the potential harm associated with radiation exposure (Pearce et al., 2012). The absolute incidence of induced lethal malignancy is estimated at 1/1000-1/5000 per cranial CT (Brenner et al., 2007).

Citations:

Brenner DJ, Hall EJ. Computed tomography — an increasing source of radiation exposure. N Engl J Med 2007; 357(22):2277-2284.

Mannix R, Meehan WP, Monuteaux MC, Bachur RG. Computed tomography for minor head injury: Variation and trends in major United States emergency departments. J Pediatr 2012; 160:136-139.

Pearce MS, Salotti JA, Little MP. et al. Radiation exposure from CT scans in childhood and subsequent risk of leukemia and brain tumours: A retrospective cohort study. Lancet 2012; 380(9840): 499–505.

4. Update to the Systematic Review of the Body of Evidence

New Studies Conducted since the Systematic Review of the Body of Evidence: The systematic review of the body of evidence primarily focuses around the yield of imaging and does not directly address the risks /harms associated with imaging. Studies related to trends in imaging use and the risks/harms associated with imaging are briefly described below.

CT use has increased in the past 20 years without an increase in the yield of imaging studies. In a cross-sectional analysis of data from the National Hospital Ambulatory Medical Care Survey, Blackwell et al. (2007) found the use of CT scans for the evaluation of children with head injury nearly doubled from 1995 to 2003 (13% to 22%); Zonfrillo et al. (2015) found evidence to suggest continued increases in CT use for ED patients with concussion from 2006 to 2011. Some research suggests that rates of imaging following head injury have declined in free-standing children's hospitals (Menoch et al., 2012; Mannix et al., 2012; Parker et al., 2015) and general EDs (Marin et al., 2014). CT rates for children with mild head injury ranged from 19% to 69% across the 25 EDs that collected data for the PECARN study (Stanley et al., 2014). Similarly, CT rates ranged from 19% to 58% for patients with minor head injury in a retrospective analysis of 5 years of hospital administrative data from 40 free-standing children's hospitals (Mannix et al., 2012).

The potential risks and harms associated with imaging include radiation exposure (Pearce et al., 2012; Mathews et al., 2013); complications from sedation and/or anesthesia (Malviya et al., 2000; Wachtel et al., 2009); incidental findings leading to potentially invasive and costly follow-up testing (Lumbreras et al., 2010; Rogers et al., 2013); and excess costs to the healthcare system, which are passed on to families (Callaghan et al., 2014).

Citations Not Included in the Systematic Review (ACR Evidence Table):

Blackwell CD, Gorelick M, Holmes JF, Bandyopadhyay S, Kuppermann N. Pediatric head trauma: Changes in use of computed tomography in emergency departments in the United States over time. Ann Emerg Med 2007; 49(3):320-324.

Callaghan BC, Kerber KA, Pace RJ, Skolarus LE, Burke JF. Headaches and neuroimaging: High utilization and costs despite guidelines. JAMA Intern Med 2014; 174(5):819-821.

Lumbreras B, Donat L, Hernández-Aquado I. Incidental findings in imaging diagnostic tests: A systematic review. Br J Radiol 2010; 83(988):276-289.

Malviya S, Voepel-Lewis T, Eldevik OP, Rockwell DT, Wong JH, Tait AR. Sedation and general anesthesia in children undergoing MRI and CT: Adverse events and outcomes. Br J Anaesth 2000; 84(6):743-748.

Mannix R, Meehan WP, Monuteaux MC, Bachur RG. Computed tomography for minor head injury: Variation and trends in major United States emergency departments. J Pediatr 2012; 160:136-139.

Marin JR, Weaver MD, Barnato AE, Yabes JG, Yealy DM, Roberts MS. Variation in emergency department head computed tomography use for pediatric head trauma. Acad Emerg Med 2014; 21(9):987-995.

Mathews JD, Forsythe AV, Brady Z, et al. Cancer risk in 680,000 people exposed to computed tomography scans in childhood or adolescence: Data linkage study of 11 million Australians. BMJ 2013; 346:f2360.

Menoch MJ, Hirsh DA, Khan NS, Simon HK, Sturm JJ. Trends in computed tomography utilization in the pediatric emergency department. Pediatrics 2012; 129(3):e690-e697.

Parker MW, Shah SS, Hall M, Fieldston ES, Coley BD, Morse RB. Computed tomography and shifts to alternate imaging modalities in hospitalized children. Pediatrics 2015; 136(3):e573-e581.

Pearce MS, Salotti JA, Little MP. et al. Radiation exposure from CT scans in childhood and subsequent risk of leukemia and brain tumours: A retrospective cohort study. Lancet 2012; 380(9840): 499–505.

Rogers AJ, Maher CO, Schunk JE, et al. Incidental findings in children with blunt head trauma evaluated with cranial CT scans. Pediatrics 2013; 132(2):e356-e363.

Stanley RM, Hoyle JD Jr, Dayan PS, et al. Emergency department practice variation in computed tomography use for children with minor blunt head trauma. J Pediatr 2014; 165(6):1201-1206.

Wachtel RE, Dexter F, Dow AJ. Growth rates in pediatric diagnostic imaging and sedation. Anesth Analg 2009; 108(5):1616-1621.

Zonfrillo MR, Kim KH, Arbogast KB. Emergency department visits and head computed tomography utilization for concussion patients from 2006 to 2011. Acad Emerg Med 2015; 22(7):872-877.

MEASURE TESTING

Measure Title: Overuse of Imaging for the Evaluation of Children with Post-Traumatic Headache

1. Data/Sample Used for All Testing of this Measure

Type of Data Used for Testing (N= Numerator; D= Denominator):

Measure is specified to use data from

- abstracted from paper record – N and D
- administrative claims – D only
- abstracted from electronic health record – N and D

Measure is tested with data from:

- abstracted from paper record – N and D
- administrative claims – D only
- abstracted from electronic health record – N and D

Dataset Used: Data used for testing were obtained from HealthCore, Inc., an independent subsidiary of Anthem, Inc., which is the largest health benefits company/insurer in the United States. HealthCore owns and operates the HealthCore Integrated Research Database (HIRD), a longitudinal database of medical and pharmacy claims and enrollment information.

Dates of the Data Used in Testing: January 1, 2011 through December 31, 2012

Levels of Analysis Tested:

- Level of Aggregation Specified: health plan
- Level of Aggregation Tested: health plan

Measured Entities included in Testing and Analysis: This measure was tested using data contained in the HIRD. The HIRD includes automated computerized claims data and enrollment information for members from 14 geographically diverse Blue Cross and/or Blue Shield (BCBS) health plans in the Northeast, South, West, and Central regions of the United States, with members living in all 50 states. The HIRD represents data from approximately 60 million lives with medical enrollment, over 37 million lives with combined medical and pharmacy enrollment information, and 16 million lives with outpatient laboratory data.

Patients included in Testing and Analysis: This measure belongs to the Q-METRIC Overuse of Imaging for the Evaluation of Children with Headache or Seizures measures collection. As part of the initial sampling strategy for testing multiple measures in this collection, approximately 2.1 million children, ages 6 months through 17 years old, were identified in the HIRD for the study's 2012 measurement year. Of these, a cohort of children with diagnosis codes for headaches and seizures were identified (57,748). Members who did not have continuous eligibility during the 2011 and 2012 calendar years were excluded, narrowing the group to 36,985 (64.0%).

Specifically for this measure, administrative claims were used to identify children, ages 2 through 17 years old, who had ICD-9-CM codes that indicated a post-traumatic headache, concussion, or general symptoms of headache evaluated in the emergency department (ED; 5,912, 16.0%). From this group, 2,967 children (50.2%) were identified as having either CT or MR imaging. After applying claims-based exclusions (suspected abuse and neglect, history of a medical condition that could warrant neuroimaging, loss of consciousness, skull fracture, and intracranial hemorrhage), 2,419 children (81.5%) were eligible to sample for chart review.

Once the population eligible for chart review was determined using administrative claims, providers associated with visits were identified. The final sampling population for chart review consisted of 1,714 children (70.9%) who could be linked to a provider having complete contact information. In an attempt to obtain an adequate number of cases to test this measure, we set a target sample of 200 abstracted charts. Patient medical records were then requested from provider offices and health care facilities for data abstraction. Patient medical records were sent to a centralized location for data abstraction. The first 204 charts received were abstracted for measure testing; 86 children (42.2%) were female, and the average age was 12.0 (SD = 3.9).

Of the 204 abstracted charts, one (0.5%) was excluded based on clinical documentation of suspected child abuse or neglect and five (2.5%) were excluded due to documentation of a medical condition that could otherwise warrant neuroimaging. There were 65 charts (31.9%) with clinical documentation of trauma occurring within 24 hours of the ED visit; among those, eight were excluded, as they had concussion as a diagnosis without evidence of a headache as a symptom, leaving 57 charts (27.9%) in the eligible study population.

Data and Testing Aspects: The administrative dataset and chart review sample described above were used for all aspects of testing.

Patient-Level Socio-Demographic (SDS) Variables: Patient-level demographic and socioeconomic characteristics were generally unavailable from the medical records reviewed for measure testing. Therefore, we used ZIP-code level race and ethnicity, median household income, and urbanicity, collected for the 2010 United States Census and the 2011 American Community Survey (ACS), as proxy variables to characterize the population. The small numbers of eligible numerator and denominator cases (n=15 and n=57, respectively) do not allow for meaningful comparisons of overuse of neuroimaging among children evaluated in EDs with post-traumatic headache across different socio-demographic groups.

Race and Ethnicity Census Characteristics

On average, children with post-traumatic headache who underwent neuroimaging resided in ZIP codes reporting primarily white race (80.2%) and modest levels of Hispanic ethnicity (9.8%). The children included in the denominator group resided in ZIP codes reporting a higher proportion of white residents (81.8%) and a similar proportion of Hispanic ethnicity (10.0%). The children included in the numerator group resided in ZIP codes reporting a still higher proportion of white residents (83.3%) and a slightly lower proportion of residents of Hispanic ethnicity (6.5%). These demographic characteristics differ from the population of the United States as a whole, as the 2010 US Census data indicates that approximately 72.4% of the population was white, 13.2% black, and 16.3% was of Hispanic ethnicity. The summary statistics for race and ethnicity within ZIP code across the sampled subgroups of children with valid ZIP codes are reported in Tables 1 and 2.

Table 1. Mean (SD) Proportion of Racial Groups within Sampled ZIP Codes of Residence‡

Sampled Group Description	American Indian or Alaska Native Mean(SD)‡	Asian Mean(SD)‡	Black or African American Mean(SD)‡	Native Hawaiian or Other Pacific Islander Mean(SD)‡	White Mean(SD)‡	Two or More Races Mean(SD)‡	Other Mean(SD)‡
Eligible children with post-traumatic headache (n=5,807)*	0.5 (1.1)	5.1 (8.0)	8.5 (13.5)	0.1 (0.2)	79.6 (17.7)	2.6 (1.4)	3.7 (6.0)
Subset who had a CT or MRI (n=2,918)**	0.5 (1.0)	4.9 (7.9)	8.0 (12.6)	0.1 (0.2)	80.2 (16.8)	2.6 (1.4)	3.7 (6.1)
Subset following claims denominator exclusions (n=2,386)***	0.5 (1.0)	4.8 (7.8)	8.2 (12.7)	0.1 (0.2)	80.3 (16.8)	2.6 (1.4)	3.6 (6.0)
Subset following claims numerator exclusions (n=1,985)****	0.5 (0.9)	4.9 (8.1)	8.1 (12.6)	0.1 (0.2)	80.3 (16.8)	2.6 (1.5)	3.6 (5.9)
Subset with reviewed and abstracted medical records (n=200)+	0.4 (0.3)	5.4 (8.1)	7.0 (10.1)	0.1 (0.3)	80.5 (15.6)	2.6 (1.4)	3.9 (6.9)
Children meeting denominator criteria (n=57)++	0.4 (0.4)	6.1 (9.1)	5.1 (8.2)	0.1 (0.1)	81.8 (15.1)	2.6 (1.3)	3.9 (7.6)
Children meeting numerator criteria (n=15)+++	0.3 (0.1)	5.2 (8.0)	6.6 (9.9)	0.03 (0.05)	83.3 (14.2)	2.0 (1.1)	2.5 (2.4)

SD = standard deviation

‡Data summarize characteristics of the broader population residing in ZIP codes of sampled cases.

*Among eligible children who had a post-traumatic headache (n=5,912), no information available for 105 members (1.8%) due to missing or unmatched ZIP code, yielding n=5,807 (98.2%).

** Among the subset of children who had a CT or MRI (n=2,967), no information available for 49 members (1.7%) due to missing or unmatched ZIP code, yielding n=2,918 (98.3%).

*** Among the subset of children following denominator exclusions (n=2,419), no information available for 33 members (1.4%) due to missing or unmatched ZIP code, yielding n=2,386 (98.6%).

**** Among the subset of children following numerator exclusions (n=2,009), no information available for 24 (1.2%) members due to missing or unmatched ZIP code, yielding n=1,985 (98.8%).

+ Among the subset of children with abstracted medical records (n=204), no information available for 4 members (2.0%) due to missing or unmatched ZIP code, yielding n=200 (98.0%).

++ Among children meeting denominator criteria (n=57), information was available for all members, yielding n=57 (100%).

+++ Among children meeting numerator criteria (n=15), information was available for all members, yielding n=15 (100%).

Table 2. Mean (SD) Proportion Reporting Hispanic Ethnicity within Sampled ZIP Codes of Residence‡

Sampled Group Description	Hispanic Ethnicity Mean (SD) ‡
Eligible children with post-traumatic headache (n=5,807)*	9.7 (13.5)
Subset who had a CT or MRI (n=2,918)**	9.8 (13.6)
Subset following claims denominator exclusions (n=2,386)***	9.5 (13.3)
Subset following claims numerator exclusions (n=1,985)****	9.4 (13.2)
Subset with reviewed and abstracted medical records (n=200)+	10.3 (14.7)
Children meeting denominator criteria (n=57)++	10.0 (13.9)
Children meeting numerator criteria (n=15)+++	6.5 (5.5)

SD = standard deviation

‡Data summarize characteristics of the broader population residing in ZIP codes of sampled cases.

*Among eligible children who had a post-traumatic headache (n=5,912), no information available for 105 members (1.8%) due to missing or unmatched ZIP code, yielding n=5,807 (98.2%).

** Among the subset of children who had a CT or MRI (n=2,967), no information available for 49 members (1.7%) due to missing or unmatched ZIP code, yielding n=2,918 (98.3%).

*** Among the subset of children following denominator exclusions (n=2,419), no information available for 33 members (1.4%) due to missing or unmatched ZIP code, yielding n=2,386 (98.6%).

**** Among the subset of children following numerator exclusions (n=2,009), no information available for 24 (1.2%) members due to missing or unmatched ZIP code, yielding n=1,985 (98.8%).

+ Among the subset of children with abstracted medical records (n=204), no information available for 4 members (2.0%) due to missing or unmatched ZIP code, yielding n=200 (98.0%).

++ Among children meeting denominator criteria (n=57), information was available for all members, yielding n=57 (100%).

+++ Among children meeting numerator criteria (n=15), information was available for all members, yielding n=15 (100%).

Socioeconomic Status – Census Characteristics

On average, the ZIP code-level median household income for children with post-traumatic headache who underwent neuroimaging was $69,540. The children in the denominator group resided in ZIP codes with higher median household incomes (mean $81,430), and those included in the numerator group resided in ZIP codes with lower median household incomes (mean $65,263). The median household income for the ZIP codes in which these children resided was substantially higher than the median household income of the population of the entire United States, as reported in the ACS in 2011, which was $50,502. The summary statistics for distribution of the ZIP-code level median household income for sampled groups of children with valid ZIP codes and complete census data are reported in Table 3.

Urbanicity – Census Characteristics

Children with post-traumatic headache who underwent neuroimaging primarily reside in urban ZIP codes (75.4%). The subset of children meeting denominator criteria resided in ZIP codes that were slightly more urban (77.9%), and those children meeting numerator criteria resided in substantially less urban ZIP codes (66.6%). The proportion of children in this sample who resided in urban ZIP codes is similar to the rest of the United States, where approximately 79% of the population resides in an urban area. The summary statistics for urbanicity within ZIP code for sampled groups of children with valid ZIP codes are reported in Table 4.

Table 3. Median Household Income within Sampled ZIP Codes of Residence‡

Sampled Group Description	Median Household Income (Mean)‡	SD	Min	25th Percentile	Median	75th Percentile	Max
Eligible children with post-traumatic headache (n=5,805)*	$69,886	$29,495	$15,473	$47,570	$63,878	$85,462	$219,688
Subset who had a CT or MRI (n=2,917)**	$69,540	$29,624	$16,036	$47,028	$63,542	$85,462	$219,688
Subset following claims denominator exclusions (n=2,386)***	$69,188	$29,630	$16,036	$46,964	$63,158	$85,380	$219,688
Subset following claims numerator exclusions (n=1,985)****	$68,934	$29,430	$16,036	$46,733	$63,269	$85,011	$219,688
Subset with reviewed and abstracted medical records (n=200)+	$74,498	$30,834	$20,673	$51,920	$69,214	$93,236	$167,037
Children meeting denominator criteria (n=57)++	$81,430	$32,839	$30,085	$57,712	$76,014	$99,041	$167,037
Children meeting numerator criteria (n=15)+++	$65,263	$28,505	$32,267	$41,500	$54,241	$86,682	$130,319

‡Data summarize characteristics of the broader population residing in ZIP codes of sampled cases.
*Among eligible children who had a post-traumatic headache (n=5,912), no information available for 107 members (1.8%) due to missing or unmatched ZIP code or missing census data, yielding n=5,805 (98.2%).
** Among the subset of children who had a CT or MRI (n=2,967), no information available for 50 members (1.7%) due to missing or unmatched ZIP code or missing census data, yielding n=2,917 (98.3%).
*** Among the subset of children following denominator exclusions (n=2,419), no information available for 33 members (1.4%) due to missing or unmatched ZIP code or missing census data, yielding n=2,386 (98.6%).
**** Among the subset of children following numerator exclusions (n=2,009), no information available for 24 members (1.2%) due to missing or unmatched ZIP code or missing census data, yielding n=1,985 (98.8%).
+ Among the subset of children with abstracted medical records (n=204), no information available for 4 members (2.0%) due to missing or unmatched ZIP code or missing census data, yielding n=200 (98.0%).
++ Among children meeting denominator criteria (n=57), information was available for all members, yielding n=57 (100%).
+++ Among children meeting numerator criteria (n=15), information was available for all members, yielding n=15 (100%).

Table 4. Proportion of Sampled ZIP Codes Categorized as Urban‡

Sampled Group Description	Urban (Mean)‡	SD	Min	25th Percentile	Median	75th Percentile	Max
Eligible children with post-traumatic headache (n=5,807)*	77.3	32.8	0	66.4	95.0	100	100
Subset who had a CT or MRI (n=2,918)**	75.4	33.7	0	63.0	93.7	100	100
Subset following claims denominator exclusions (n=2,386)***	74.5	34.2	0	61.6	93.0	100	100
Subset following claims numerator exclusions (n=1,985)****	74.0	34.5	0	61.1	92.9	100	100
Subset with reviewed and abstracted medical records (n=200)+	77.5	32.3	0	63.6	95.2	100	100
Children meeting denominator criteria (n=57)++	77.9	30.9	0	68.3	94.2	100	100
Children meeting numerator criteria (n=15)+++	66.6	37.8	0	29.6	74.2	100	100

‡Data summarize characteristics of the broader population residing in ZIP codes of sampled cases.

*Among eligible children who had a post-traumatic headache (n=5,912), no information available for 105 members (1.8%) due to missing or unmatched ZIP code, yielding n=5,807 (98.2%).

** Among the subset of children who had a CT or MRI (n=2,967), no information available for 49 members (1.7%) due to missing or unmatched ZIP code, yielding n=2,918 (98.3%).

*** Among the subset of children following denominator exclusions (n=2,419), no information available for 33 members (1.4%) due to missing or unmatched ZIP code, yielding n=2,386 (98.6%).

**** Among the subset of children following numerator exclusions (n=2,009), no information available for 24 (1.2%) members due to missing or unmatched ZIP code, yielding n=1,985 (98.8%).

+ Among the subset of children with abstracted medical records (n=204), no information available for 4 members (2.0%) due to missing or unmatched ZIP code, yielding n=200 (98.0%).

++ Among children meeting denominator criteria (n=57), information was available for all members, yielding n=57 (100%).

+++ Among children meeting numerator criteria (n=15), information was available for all members, yielding n=15 (100%).

2. Reliability Testing

Level of Reliability Testing: Critical data elements used in the measure

3. Validity Testing

Level of Validity Testing: Critical data elements used in the measure; systematic assessment of face validity of performance measure score as an indicator of quality or resource use

Method and Steps of Validity Testing

Validity of Exclusion Criteria

Denominator: We tested the validity of administrative claims to exclude cases from the denominator based on two ICD-9-CM code-based criteria: 1) suspected child abuse and neglect and 2) history of a medical condition that could otherwise warrant neuroimaging; claims data were tested against medical records, which are considered the gold standard of clinical documentation. Children with ICD-9-CM codes associated with these claims-based exclusions were removed from the chart review sample. In other words, none of the charts sampled for medical record review contained ICD-9-CM codes associated with these claims-based exclusions. We tested the accuracy of the assumption that the absence of these ICD-9-CM codes in administrative claims would mean the absence of clinical documentation indicative of these exclusionary conditions in the medical record.

Numerator: We tested administrative claims against chart review data to determine the potential to exclude cases from the numerator using administrative claims for two numerator criteria: 1) seizure or convulsion and 2) indicators of increased intracranial pressure. Data for these two numerator criteria were abstracted from charts, and ICD-9-CM codes were identified in administrative claims. The medical chart was considered the gold standard. Sensitivity, specificity, and negative and positive predictive values were calculated.

Conversion of ICD-9-CM to ICD-10-CM Codes

The goal of ICD-9-CM to ICD-10-CM conversion was to translate this measure to a new code set, fully consistent with the intent of the original measure. All ICD-9-CM diagnosis codes were converted to ICD-10-CM codes using the Centers for Medicare and Medicaid Services (CMS) 2015 diagnosis code General Equivalence Mappings (GEM) and diagnosis code description files, accessed on August 26, 2015. The ICD-9-CM codes were converted to ICD-10-CM using the GEM file and manually reviewed for consistency using the diagnosis code descriptions for the source ICD-9-CM and converted ICD-10-CM codes. In addition, the resultant ICD-10-CM codes were back-translated to ICD-9-CM to verify the accuracy of the coding. Source files from CMS were acquired from these files:

ICD-9 to 10 diagnosis GEM -2015_I9gem.txt https://www.cms.gov/Medicare/Coding/ICD10/2015-ICD-10-CM-and-GEMs.html

ICD-10 to 9 diagnosis GEM - 2015_10gem.txt https://www.cms.gov/Medicare/Coding/ICD10/2015-ICD-10-CM-and-GEMs.html

ICD-9 description file - CMS32_DESC_SHORT_DX.txt https://www.cms.gov/Medicare/Coding/ICD9ProviderDiagnosticCodes/codes.html

ICD-10 description file - icd10cm_order_2015.txt https://www.cms.gov/Medicare/Coding/ICD10/2015-ICD-10-CM-and-GEMs.html

The resultant ICD-10-CM codes were clinically reviewed. We removed the ICD-10-CM code G44.32x (chronic post-traumatic headache), as this measure is focused on imaging that occurs within 24 hours of an injury. The chronicity of a post-traumatic headache was not characterized in ICD-9-CM codes. We also excluded ICD-10-CM codes specific to psychological abuse and observation following alleged adult physical abuse. The original list of ICD-9-CM codes included one E-code (E934.2 Anticoagulants causing adverse effects in therapeutic use) that did not convert to an ICD-10-CM code.

ICD-9-CM procedure codes for head CT and brain MRI were converted using an online tool: http://www.icd10data.com/Convert.

Validity of Data Abstraction from the Medical Record

Validity of medical record data was determined through re-abstraction of patient record data by a senior abstractor, considered the gold standard for medical record review. We calculated the inter-rater reliability (IRR) comparing abstractors with the senior abstractor. IRR was determined by calculating percent agreement and Cohen's kappa statistic. Sensitivity, specificity, and negative and positive predictive values were calculated.

Face Validity of Performance Measure Score

The face validity of this measure was established by a national panel of experts and parent representatives for families of children with headache and seizures convened by Q-METRIC. The Q-METRIC panel included nationally recognized experts in the area of imaging children, representing general pediatrics, pediatric radiology, pediatric neurology, pediatric neurosurgery, pediatric emergency medicine, general emergency medicine, and family medicine. In addition, measure validity was considered by experts in state Medicaid program operations, health plan quality measurement, health informatics, and health care quality measurement. In total, the Q-METRIC imaging panel included 15 experts, providing a comprehensive perspective on imaging children and the measurement of quality metrics for states, health plans, and EDs. The expert panel assessed whether the performance of this measure would result in improved quality of care for children with headache and seizures in relation to neuroimaging. Specifically, the panel weighed the evidence to determine if this measure of overuse could reduce unnecessary imaging among children with post-traumatic headache. The voting process to prioritize the measure was based on the ability of the measure to distinguish good from poor quality.

Statistical Results from Validity Testing:

Validity of Exclusion Criteria

Denominator: Of the 204 charts reviewed, one (0.5%) had clinical documentation of suspected child abuse or neglect and five (2.5%) contained clinical documentation of a medical condition that could otherwise warrant neuroimaging in the absence of ICD-9-CM codes associated with these two claims-based denominator exclusions. Therefore, 97% (198 of 204) of the charts reviewed were in agreement with the administrative claims regarding the absence of these denominator exclusions.

Numerator: Among children eligible for the denominator after chart review (n=57), the sensitivity of claims for identification of seizure was 0% (95% CI; 0.0, 97.5) and the specificity was 100% (95% CI; 93.6, 100); positive predictive value could not be calculated because there were no true or false positives and negative predictive value was 98.3% (95% CI; 90.6, 99.9). The sensitivity of claims for identification of indicators of increased intracranial pressure was 8.1% (95% CI; 1.7, 21.9) and the specificity was 90.0% (95% CI; 68.3, 98.8); positive predictive value was 60.0% (95% CI; 14.7, 94.7) and negative predictive value was 34.6% (95% CI; 22.0, 49.1). Contingency tables for both variables are shown below (Tables 5 and 6).

Table 5: Contingency Table for Presence of Seizure in Administrative Claims and Charts

		Evidence of Seizure or Convulsions Documented in Charts		
		Present	Absent	Total
Seizure in Claims Based on ICD-9-CM Codes*	Present	0	1	1
	Absent	0	56	56
	Total	0	57	57

*ICD-9-CM codes for seizure 345.2x, 345.3x, 780.33, 780.39.

Table 6: Contingency Table for Presence of Indicators of Increased Intracranial Pressure in Administrative Claims and Charts

		Evidence of Indicators of Increased Intracranial Pressure (ICP) in Charts		
		Present	Absent	Total
Indicators of Increased ICP in Claims Based on ICD-9-CM Codes**	Present	3	34	37
	Absent	2	18	20
	Total	5	52	57

**ICD-9-CM codes for indicators of increased intracranial pressure: 368.2x, 374.3x, 377.0x, 387.5x, 379.50, 386.2x, 780.02, 780.03, 780.09, 780.4x, 780.97, 781.2x - 781.4x, 781.93, 536.2x, 781.94, 780.0x, 379.41, 348.4x, 348.5x.

Conversion of ICD-9-CM to ICD-10-CM Codes

We found the majority of ICD-9-CM codes used to narrow the number of eligible charts to sample for chart review for the calculation of this measure mapped to ICD-10-CM codes that remain relevant to our intended specifications. This measure could not be tested in administrative data using ICD-10-CM codes since this testing occurred prior to the clinical adoption of ICD-10-CM coding.

Validity of Data Abstraction from the Medical Record

Of the 204 abstracted medical records, 30 (15%) were reviewed for IRR; percent agreement and kappa were calculated. IRR was assessed by comparing individual abstractor agreement with a senior abstractor as the gold standard on the 16 data elements abstracted from charts for this measure (corresponding to 441 eligible items after accounting for skip patterns). Disagreement was identified for two of the 16 data elements: 1) Was there documentation of increased intracranial pressure? (Indications include: swelling of the optic disc (papilledema), double vision (diplopia), abnormal face or eye movements, dizziness (vertigo), abnormal gait (ataxia), abnormal coordination (dysmetria), confusion); percent agreement was 96.7% (kappa 0.84). 2) Was there documentation of altered mental status including comments such as "not acting like himself" per parent report?; percent agreement was 96.7% (kappa 0.90).

Overall, abstractor agreement was 99.3% (kappa 0.98). The sensitivity of the abstractors to identify chart-based exclusions compared with the senior abstractor was 100% (95% CI; 94.6, 100); specificity was 99.5% (95% CI; 98.1, 99.9); positive predictive value was 97.1% (95% CI; 89.9, 99.7) and negative predictive value was 100% (95% CI; 99.0, 100.0). The related contingency table is below (Table 7).

Table 7: Contingency Table for Presence of Chart Review Exclusions

		Senior Abstractor Identified Chart-Based Exclusion		
		Present	Absent	Total
Abstractor Identified Chart-Based Exclusion	Present	67	2	69
	Absent	0	372	372
	Total	67	374	441

Face Validity of Performance Measure Score

The Q-METRIC expert panel concluded that this measure has a high degree of face validity through a detailed review of concepts and metrics considered to be essential to the appropriate imaging of children. Concepts and draft measures were rated by this group for their relative importance. This measure was highly rated, receiving an average score of 7.0 (with 9 as the highest possible score). In addition, the expert panel concluded that this measure of overuse of neuroimaging for the evaluation of children with post-traumatic headache could reduce unnecessary imaging for this population of children, and the measure would be able to distinguish good from poor quality.

How Do Results Demonstrate Validity?

Validity of Exclusion Criteria

Denominator: Our results demonstrate that we were able to exclude nearly all children with clinical evidence of child abuse or neglect or a medical condition that could otherwise warrant neuroimaging through exclusions based on associated ICD-9-CM codes present in administrative claims. Therefore, the use of administrative claims is an appropriate and valid method to narrow the population of charts sampled within this measure specification. However, the presence of these exclusionary conditions in the medical record indicates that medical record abstraction is necessary to accurately identify these two denominator exclusions. The abstraction of this information should be conducted in conjunction with the chart review necessary to identify children with post-traumatic headache, an ED visit within 24 hours of trauma, and the numerator exclusions required for calculation of this measure.

Numerator: The low sensitivity of administrative claims compared with the gold standard of the medical record for the two variables tested indicates that chart review is required for the accurate and complete collection of numerator exclusion criteria.

This measure relies on chart review for the identification of inclusion criteria for which there are no ICD-9-CM codes (e.g., documentation of trauma within 24 hours of the ED visit). Chart review also provides a secondary opportunity to identify exclusion criteria that may not fully be captured in ICD-9-CM codes contained in administrative data. Therefore, we conclude that administrative claims alone are insufficient for calculating neuroimaging overuse percentages at this time.

Conversion of ICD-9-CM to ICD-10-CM Codes

The ICD-9-CM to ICD-10-CM code mapping procedure outlined above can be applied to obtain relevant ICD-10-CM codes for the identification of charts eligible for the chart review sample for the calculation of this measure.

Validity of Data Abstraction from the Medical Record

A kappa of greater than 0.81 is considered almost perfect agreement (Landis and Koch, 1977). A percent agreement of 99.3% and kappa statistic of 0.98 indicate that a very high level of agreement was achieved. Given this evidence, the data elements needed for calculation of the measure can be abstracted with a high degree of accuracy.

Citation

Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977; 33:159-174.

Face Validity of Measure

Given the high rating assigned by the Q-METRIC expert panel, we feel this measure has a very high degree of face validity.

Exclusion Analysis

Method of Testing Exclusions: There are several exclusion criteria that can be applied to administrative claims to narrow the population eligible for chart review. The degree to which these exclusion criteria affect overuse percentage calculations is unknown. Therefore, we performed a sensitivity analysis of exclusion criteria described below.

Among 2,967 children who visited the ED with a post-traumatic headache, concussion without loss of consciousness, or general headache and underwent CT or MRI, 450 children (15.2%) had the presence of at least one ICD-9-CM code indicative of child abuse and neglect, loss of consciousness, skull fracture, or intracranial hemorrhage. This group of ICD-9-CM codes was flagged as present or absent in the administrative data available to the Q-METRIC team. Claims-based exclusions for medical conditions that could otherwise warrant neuroimaging (n=98) were applied to the denominator with a unique flag. Claims-based exclusions for indicators of increased intracranial pressure (n=343) and seizure/convulsions (n=67) were applied to the numerator with unique flags.

To perform the sensitivity analysis of exclusion criteria (Table 8), we varied the number of children among the 450 (originally classified as having abuse/neglect, or loss of consciousness, skull fracture, or intracranial hemorrhage) with the denominator exclusion of child abuse and neglect by 25%, 50%, 90% and 100%. In each scenario, children who were not excluded for abuse/neglect were counted as having numerator exclusions for loss of consciousness, skull fracture, or intracranial hemorrhage. We held constant the claims-based exclusions for medical conditions that could otherwise warrant neuroimaging (increased intracranial pressure, seizure/convulsions). In each scenario, we calculated the overuse percentage based solely on administrative claims data.

In the sample of abstracted charts (n=204), we determined the overuse percentage (Table 9) using exclusions that were identified in administrative claims before chart review. We subsequently calculated the overuse percentage using criteria abstracted during medical record review.

Statistical Results from Testing Exclusions:

Table 8: Sensitivity Analysis with Variation in Claims-Based Exclusion Criteria among Children with Neuroimaging during an ED Visit for Post-Traumatic Headache, Concussion, or General Headache, N = 2967

	% Variation in Number of Children with Denominator Exclusion for Child Abuse and Neglect				
	0%	25%	50%	90%	100%
DENOMINATOR EXCLUSIONS					
Abuse and neglect	450	333	225	45	0
Medical conditions that could otherwise warrant neuroimaging	98	98	98	98	98
DENOMINATOR	2,419	2,536	2,644	2,824	2,869
NUMERATOR EXCLUSIONS					
Loss of consciousness, skull fracture, intracranial hemorrhage	0	117	225	405	450
Indicators of increased intracranial pressure	343	343	343	343	343
Seizure or convulsions	67	67	67	67	67
NUMERATOR	2,009	2,009	2,009	2,009	2,009
Overuse percentage using administrative claims	83.0%	79.2%	76.0%	71.1%	70.0%

Table 9: Overuse Percentage within the Chart Review Sample using Claims or Chart Review Criteria

	Chart Review Sample N=204	
	Criteria identified in Claims	Criteria identified in Charts
Denominator	198	57
Numerator	187	15
Overuse percentage	94.4%	26.3%

How Do Results Demonstrate the Necessity of Exclusions? The results of the exclusion analysis demonstrate that without the use of chart review, the overuse percentage would be substantially over-estimated 56 to 68 percentage points. Although the initial application of ICD-9-CM code-based exclusions decreases the burden of reviewing charts unlikely to meet final inclusion criteria for calculation of this measure as specified, the application of exclusions obtained exclusively from chart review substantially changes the neuroimaging overuse percentage compared with claims alone. Therefore, identification of exclusions in both administrative claims and chart review are necessary for calculation of this measure. Lastly, it is important to note that there are key elements for this measure that cannot be captured in any form using administrative claims. For example, there are currently no ICD-9-CM or ICD-10-CM codes for the major inclusion criteria of having an injury within 24 hours of the ED visit. The vast differences between overuse percentages calculated using data available in administrative claims alone and through chart review justify the burden of chart review for the calculation of this measure.

4. Risk Adjustment/Stratification for Outcome Measures

Method Used to Control for Differences in Case Mix: No risk adjustment or stratification necessary

5. Identification of Statistically Significant and Meaningful Differences in Performance

Method Used Determining if Statistically Significant and Clinically/Practically Meaningful Differences in Performance Measure Scores among the Measured Entities can be Identified:
We calculated a single neuroimaging overuse percentage for the evaluation of children with post-traumatic headache within a sample of charts obtained by HealthCore after cases were narrowed using administrative claims from the HIRD. Due to the small sample size of charts eligible for inclusion in the numerator and denominator after chart review, we were unable to perform comparisons between health plans or hospital EDs.

A two-sided two-proportion z-test was conducted to determine if the observed overuse percentage in our sample was statistically different than the observed rate of overuse within the 2009 PECARN study of children with traumatic brain injury, which was undertaken to develop a clinical decision rule for CT imaging. In addition, we conducted a one-sided one-proportion z-test to determine if the observed overuse percentage in our sample was greater than a theoretical target overuse percentage of 5%.

In order to inform future applications of this measure, we calculated the sample size needed to achieve 95% confidence intervals with half widths of 2.5%, 5%, and 8% for anticipated overuse percentages ranging from 5% to 25%. We also calculated the per group sample size needed to detect 5% to 20% differences in two proportions with power of 80, 90, and 95. We used a control overuse percentage of 15% for this calculation.

Statistical Results from Testing the Ability to Identify Statistically Significant and/or Clinically/Practically Meaningful Differences in Performance Measure: The overuse percentage in our chart review sample was 26.3%. The sample sizes needed to achieve 95% confidence intervals with half widths of 2.5%, 5%, and 8% for anticipated overuse percentages ranging from 5% to 25% are presented in Table 10.

Table 10: Sample Size Calculation for 95% Confidence Intervals around Expected Overuse Percentages

Expected Overuse Proportion	Required Sample Size for CI half-width=2.5%	Required Sample Size for CI half-width=5%	Required Sample Size for CI width=8%
5.0%	292	73	N/A
8.0%	292	114	45
10.0%	554	139	55
15.0%	784	196	77
20.0%	984	246	97
25.0%	1153	289	113

When comparing our overuse percentage (26.3%) with the rate of imaging in children lacking all of the six predictors of clinically important traumatic brain injury in the PECARN derivation sample (21.1%), a z-score of 0.9478 was obtained, corresponding to a two-sided p-value of 0.342. When comparing our overuse percentage (26.3%) with the rate of imaging in children lacking all of the six predictors of clinically important traumatic brain injury in the PECARN validation sample (20.1%), a z-score of 1.1606 was obtained, corresponding to a two-sided p-value of 0.246. When comparing our observed overuse percentage with the theoretical target overuse percentage of 5%, a z-score of 7.379 was obtained, corresponding to a one-sided p-value of <0.001. The results of our sample size calculation to guide future testing of this measure are presented in Table 11.

Table 11: Per Group Sample Size for Two-Sample Proportion Test (control proportion 15%)

Power	5% Difference	10% Difference	15% Difference	20% Difference
80	906	250	121	73
90	1,212	335	161	97
95	1,498	413	199	119

How Do Results Demonstrate the Ability to Identify Statistically Significant and/or Clinically/Practically Meaningful Differences? With the small number of charts eligible for our overuse percentage calculations, we were unable to test for differences between health plans, sites, and providers. This measure was successfully able to distinguish statistically significant differences ($p<0.05$) in overuse of imaging from the theoretical target percentage of 5%. The overuse percentage in this sample was significantly higher than a target percentage of 5%, which indicates less than optimal performance. Sample size calculations for both 95% confidence interval half-widths and two-sample proportion tests are provided to guide appropriate sample size targets for use of this measure in quality improvement and quality performance reporting. A minimum of 196 charts included in the denominator after chart review would be recommended to obtain a 95% confidence interval with a 5% half-width around an expected overuse percentage of 15%. A per group minimum of 335 charts included in the denominator after chart review would be recommended for a two-sample proportion test to detect a 10% difference from a control proportion of 15% with power of 0.90 and alpha of 0.05.

Overuse of Imaging

Overuse of Imaging for the Evaluation of Children with Post-Traumatic Headache

Description

The percentage of children, ages 2 through 17 years old, with post-traumatic headache who were evaluated in the emergency department (ED) within 24 hours after an injury, and imaging of the head [computed tomography (CT) or magnetic resonance imaging (MRI)] was obtained in the absence of documented neurologic signs or symptoms that suggest intracranial hemorrhage or basilar skull fracture. A lower percentage indicates better performance, as reflected by use of imaging only when indicated.

Calculation

This measure of imaging overuse requires administrative and medical record data and is calculated as a percentage as follows:

> The number of children with post-traumatic headache for whom imaging of the head (CT or MRI) was obtained in the absence of documented neurologic signs or symptoms that suggest intracranial hemorrhage or basilar skull fracture divided by the number of eligible children with post-traumatic headache for whom imaging of the head (CT or MRI) was obtained (numerator divided by denominator times 100%).

Eligible Population

Determination of the eligible population for this measure requires administrative and medical record data.

Ages	Children 2 years or older on January 1 of the measurement year but younger than 18 years on December 31 of the measurement year
Enrollment	Continuous insurance-plan enrollment during both the measurement year and the year prior to the measurement year
Event/Diagnosis	Imaging studies of the head [*based on Uniform Billing (UB-92) Revenue codes, Current Procedural Terminology (CPT) codes or International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9-CM) codes for head CT or MRI listed in Table IMG1*] obtained for the evaluation of post-traumatic headache *(based on ICD-9-CM codes listed in Table IMG2 and clinical documentation)*, in association with an ED visit (*based on UB92 Revenue codes and CPT codes listed in Table IMG3)* within 24 hours of injury (*based on clinical documentation*).

*ICD-9-CM to ICD-10-CM code conversions are presented in the Tables where appropriate.

Specification

Denominator The number of children, ages 2 through 17 years old, with post-traumatic headache who were evaluated in the ED within 24 hours after an injury, and imaging of the head was obtained in the absence of suspected child abuse or neglect (*based on ICD-9-CM codes listed in Table IMG4 or clinical documentation*) or a condition that could otherwise warrant neuroimaging (*based on ICD-9-CM codes listed in Table IMG5 or clinical documentation*).

Numerator The number of children eligible for the denominator for whom imaging of the head (CT or MRI) was obtained in the absence of documented neurologic signs or symptoms that suggest intracranial hemorrhage (*based on clinical documentation*) or basilar skull fracture (*based on clinical documentation*).

Exclusions

- Children younger than 2 years of age or older than 17 years of age at the time of the ED evaluation of post-traumatic headache
- **Denominator Exclusions**
  - Exclusions based on ICD-9-CM codes captured in administrative claims data:
    - Suspected abuse/neglect
      - Based on relevant ICD-9-CM codes (Table 4) associated with health care received on the day of or within 7 days prior to neuroimaging
    - Medical history that could otherwise warrant neuroimaging
      - Based on ICD-9-CM codes (Table 5) associated with health care received on the day of or within the 365 days before the imaging was obtained
  - Exclusions based on clinical documentation:
    - Suspected abuse/neglect noted during the ED visit during which neuroimaging was obtained
    - Medical history noted during the ED visit during which neuroimaging was obtained that could otherwise warrant imaging (e.g., neoplasm and blood disorder, hydrocephalus and CNS anomalies, tuberous sclerosis, dwarfism, hemangioma, phlebitis/thrombophlebitis, intracranial hemorrhage, occlusion of cerebral arteries, moyamoya disease, congenital heart disease, anticoagulation)
    - No clinical documentation of headache as a symptom in cases where inclusion was based only on an ICD-9-CM code for concussion (8500)

- No clinical documentation of trauma history in cases where inclusion was based only on an ICD-9-CM code for headache (7840)
- Time of the injury was not documented in the medical record
- Time of the injury was documented to be greater than 24 hours prior to the time of the ED visit

- **<u>Numerator Exclusions (All are based on clinical documentation)</u>**
    - Severe mechanism of injury (e.g., penetrating trauma, fall from more than 5 feet, pedestrian struck by vehicle)
    - History of seizure or convulsions associated with trauma
    - History of loss of consciousness associated with trauma
    - Repeated vomiting
    - Documented basilar skull fracture
    - Suspected basilar skull fracture based on the following examination findings:
        - "Raccoon eyes" (bruising around the eyes/black eyes), Battle's sign (bruising behind one or both ears), hemotympanum (blood behind one or both ear drums)
    - Absence of documented neurologic examination
    - Abnormal neurologic examination or signs or symptoms of intracranial hemorrhage or increased intracranial pressure:
        - Decreased alertness or confusion, including comments such as "not acting like himself" per parent report
        - Altered mental status or Glasgow Coma Scale Score <14
        - Papilledema
        - Diplopia
        - Abnormal face or eye movements
        - Asymmetric face or extremity muscle movements
        - Altered sensation
        - Dizziness
        - Gait disturbance
        - Lack of coordination

Example chart review data abstraction tool provided at the end of this document.

Table IMG1: Codes to Identify Neuroimaging in Administrative Claims with ICD-10-CM Code Conversion

Imaging Modality	Code Type	Codes
Head CT	Revenue (UB-92)	350, 351, 352, 353, 354, 355, 356, 357, 358, 359
	CPT	70450, 70460, 70470, 70480,
	ICD-9-CM**	87.03
Brain MRI	Revenue (UB-92)	610, 611, 612, 613, 614, 615, 616, 617, 618, 619
	CPT	70551, 70552, 70553
	ICD-9-CM***	88.91

**ICD-10-CM Code for Head CT: B02000Z, B0200ZZ, B02010Z, B0201ZZ, B020Y0Z, B020YZZ, B020ZZZ
***ICD-10CM Code for Head MRI: B020Y0Z, B030YZZ, B030ZZZ

Table IMG2: ICD-9-CM Codes to Identify Population with Post-Traumatic Headache with ICD-10-CM Code Conversion

Post-Traumatic Headache ICD-9-CM Code Description	ICD-9-CM Code	ICD-10-CM Code	ICD-10-CM Code Description
Post-traumatic headache	33920	G44309	Post-traumatic headache, unspecified, not intractable
Post-traumatic headache	33921	G44319	Acute post-traumatic headache, not intractable
Acute pain due to trauma	33811	G8911	Acute pain due to trauma
Headache	7840	R51	Headache
Concussion with no loss of consciousness	8500	S060X0A	Concussion without loss of consciousness, initial encounter

Table IMG3: Codes to Identify Emergency Department Visits

UB92 Revenue Codes	Between 450 and 459
	In 516, 526, 981
CPT Codes	Between 99281 and 99285
	99288

Table IMG 4: ICD-9-CM Codes to Identify Child Abuse or Neglect with ICD-10-CM Code Conversion

Child Abuse or Neglect ICD-9-CM Code Description	ICD-9-CM Code	ICD-10-CM Code	ICD-10-CM Code Description
Child abuse and neglect	9955	T7402XA	Child neglect or abandonment, confirmed, initial encounter
Child abuse and neglect	9955	T744XXA	Shaken infant syndrome, initial encounter
Child abuse and neglect	9955	T7612XA	Child physical abuse, suspected, initial encounter
Child abuse and neglect	9955	T7622XA	Child sexual abuse, suspected, initial encounter
Child abuse and neglect	9955	T7422XA	Child sexual abuse, confirmed, initial encounter
Child abuse and neglect	9955	T7402XA	Child neglect or abandonment, confirmed, initial encounter
Child abuse and neglect	9955	T7492XA	Unspecified child maltreatment, confirmed, initial encounter
Child abuse and neglect	9955	T7492XA	Unspecified child maltreatment, confirmed, initial encounter
Child abuse and neglect	9955	T7692XA	Unspecified child maltreatment, suspected, initial encounter
Child abuse and neglect	9955	T7412XA	Child physical abuse, confirmed, initial encounter
Child abuse and neglect	9955	T7602XA	Child neglect or abandonment, suspected, initial encounter
Child abuse and neglect	9955	T7692XA	Unspecified child maltreatment, suspected, initial encounter
Observation and evaluation for – abuse and neglect	V7181	Z0472	Encounter for exam and observation following alleged child physical abuse

Table IMG5: ICD-9-CM Codes to Identify Other Conditions that Potentially Warrant Imaging for Evaluation of Post-Traumatic Headache with ICD-10-CM Code Conversion

Other Conditions ICD-9-CM Code Description	ICD-9-CM Code	ICD-10-CM Code	ICD-10-CM Code Description
Malignant neoplasm of brain	1915	C715	Malignant neoplasm of cerebral ventricle
Malignant neoplasm of brain	1911	C711	Malignant neoplasm of frontal lobe
Malignant neoplasm of brain	1914	C714	Malignant neoplasm of occipital lobe
Malignant neoplasm of brain	1919	C719	Malignant neoplasm of brain, unspecified
Malignant neoplasm of brain	1913	C713	Malignant neoplasm of parietal lobe
Malignant neoplasm of brain	1918	C718	Malignant neoplasm of overlapping sites of brain
Malignant neoplasm of brain	1917	C717	Malignant neoplasm of brain stem
Malignant neoplasm of brain	1912	C712	Malignant neoplasm of temporal lobe
Malignant neoplasm of brain	1910	C710	Malignant neoplasm of cerebrum, except lobes and ventricles
Malignant neoplasm of brain	1916	C716	Malignant neoplasm of cerebellum
Malignant neoplasm of pituitary gland	1943	C752	Malignant neoplasm of craniopharyngeal duct
Malignant neoplasm of pituitary gland	1943	C751	Malignant neoplasm of pituitary gland
Malignant neoplasm of pineal gland	1944	C753	Malignant neoplasm of pineal gland
Secondary malignant neoplasm of other sites - brain	1983	C7931	Secondary malignant neoplasm of brain
Benign neoplasm of brain	2250	D332	Benign neoplasm of brain, unspecified
Benign neoplasm of cranial nerves	2251	D333	Benign neoplasm of cranial nerves
Benign neoplasm of cerebral meninges	2252	D329	Benign neoplasm of meninges, unspecified
Benign neoplasm of cerebral meninges	2252	D320	Benign neoplasm of cerebral meninges
Neoplasm of uncertain behavior - pituitary	2370	D444	Neoplasm of uncertain behavior of craniopharyngeal duct
Neoplasm of uncertain behavior - pituitary	2370	D443	Neoplasm of uncertain behavior of pituitary gland
Neoplasm of uncertain behavior - pineal gland	2371	D445	Neoplasm of uncertain behavior of pineal gland

Other Conditions ICD-9-CM Code Description	ICD-9-CM Code	ICD-10-CM Code	ICD-10-CM Code Description
Neurofibromatosis	23779	Q8509	Other neurofibromatosis
Neurofibromatosis	23773	Q8503	Schwannomatosis
Neurofibromatosis	23772	Q8502	Neurofibromatosis, type 2
Neurofibromatosis	23771	Q8501	Neurofibromatosis, type 1
Neurofibromatosis	23770	Q8500	Neurofibromatosis, unspecified
Personal history of malignant neoplasm of brain	V1085	Z85841	Personal history of malignant neoplasm of brain
Sickle cell disease	28260	D571	Sickle-cell disease without crisis
Sickle cell disease	28260	D571	Sickle-cell disease without crisis
Pancytopenia	28419	D61818	Other pancytopenia
Pancytopenia	28412	D61811	Other drug-induced pancytopenia
Pancytopenia	28411	D61810	Antineoplastic chemotherapy induced pancytopenia
Coagulation defects	2869	D689	Coagulation defect, unspecified
Coagulation defects	2869	D688	Other specified coagulation defects
Coagulation defects	2867	D684	Acquired coagulation factor deficiency
Coagulation defects	2867	D6832	Hemorrhagic disord d/t extrinsic circulating anticoagulants
Coagulation defects	2866	D65	Disseminated intravascular coagulation
Coagulation defects	28659	D68318	Oth hemorrhagic disord d/t intrns circ anticoag,antib,inhib
Coagulation defects	28653	D68312	Antiphospholipid antibody with hemorrhagic disorder
Coagulation defects	28652	D68311	Acquired hemophilia
Coagulation defects	2864	D680	Von Willebrand's disease
Coagulation defects	2863	D682	Hereditary deficiency of other clotting factors
Coagulation defects	2862	D681	Hereditary factor XI deficiency
Coagulation defects	2861	D67	Hereditary factor IX deficiency
Coagulation defects	2860	D66	Hereditary factor VIII deficiency
Qualitative platelet defects	2871	D691	Qualitative platelet defects
Primary thrombocytopenia	28731	D693	Immune thrombocytopenic purpura
Primary thrombocytopenia	28730	D6949	Other primary thrombocytopenia
Primary thrombocytopenia	28733	D6942	Congenital and hereditary thrombocytopenia purpura
Primary thrombocytopenia	28732	D6941	Evans syndrome
Primary thrombocytopenia	28731	D693	Immune thrombocytopenic purpura
Primary thrombocytopenia	28739	D693	Immune thrombocytopenic purpura
Primary thrombocytopenia	28730	D6949	Other primary thrombocytopenia
Primary thrombocytopenia	28739	D6949	Other primary thrombocytopenia
Primary thrombocytopenia	28739	D693	Immune thrombocytopenic purpura
Primary thrombocytopenia	28739	D6949	Other primary thrombocytopenia
2ndary thrombocytopenia	28749	D6959	Other secondary thrombocytopenia
2ndary thrombocytopenia	28741	D6951	Posttransfusion purpura
Thrombocytopenia, unspecified	2875	D696	Thrombocytopenia, unspecified
Other specified hemorrhagic conditions	2878	D698	Other specified hemorrhagic conditions
Unspecified hemorrhage conditions	2879	D699	Hemorrhagic condition, unspecified

Other Conditions ICD-9-CM Code Description	ICD-9-CM Code	ICD-10-CM Code	ICD-10-CM Code Description
Primary hypercoagulable state	28981	D6861	Antiphospholipid syndrome
Primary hypercoagulable state	28981	D6862	Lupus anticoagulant syndrome
Primary hypercoagulable state	28981	D6852	Prothrombin gene mutation
Primary hypercoagulable state	28981	D6859	Other primary thrombophilia
Primary hypercoagulable state	28981	D6851	Activated protein C resistance
2ndary hypercoagulable state	28982	D6869	Other thrombophilia
Long-term (current) use of anticoagulants	V5861	Z7901	Long term (current) use of anticoagulants
Long-term (current) use of antiplatelets/ antithrombotics	V5863	Z7902	Long term (current) use of antithrombotics/antiplatelets
Obstructive hydrocephalus	3314	G911	Obstructive hydrocephalus
Congenital hydrocephalus	7423	Q031	Atresia of foramina of Magendie and Luschka
Congenital hydrocephalus	7423	Q038	Other congenital hydrocephalus
Congenital hydrocephalus	7423	Q030	Malformations of aqueduct of Sylvius
Spina bifida with hydrocephalus	74103	Q052	Lumbar spina bifida with hydrocephalus
Spina bifida with hydrocephalus	74102	Q051	Thoracic spina bifida with hydrocephalus
Spina bifida with hydrocephalus	74101	Q050	Cervical spina bifida with hydrocephalus
Spina bifida with hydrocephalus	74100	Q0703	Arnold-Chiari syndrome with spina bifida and hydrocephalus
Spina bifida with hydrocephalus	74100	Q054	Unspecified spina bifida with hydrocephalus
Spina bifida with hydrocephalus	74100	Q0702	Arnold-Chiari syndrome with hydrocephalus
Mechanical complication of CNS device, implant, graft	9962	T85192A	Mech compl of implnt electrnc neurostim of spinal cord, init
Mechanical complication of CNS device, implant, graft	9962	T8509XA	Mech compl of ventricular intracranial shunt, init
Mechanical complication of CNS device, implant, graft	9962	T85199A	Mech compl of implnt electrnc stimultr of nervous sys, init
Mechanical complication of CNS device, implant, graft	9962	T85190A	Mech compl of implanted electronic neurostim of brain, init
Infection and inflammatory reaction due to CNS device...	99663	T8579XA	Infect/inflm reaction due to oth int prosth dev/grft, init
Other complications of internal prosthetic device, implant…	99675	T8582XA	Fibrosis due to internal prosth dev/grft, NEC, init
Other complications of internal prosthetic device, implant…	99675	T8589XA	Oth complication of internal prosth dev/grft, NEC, init
Other complications of internal prosthetic device, implant…	99675	T8586XA	Thrombosis due to internal prosth dev/grft, NEC, init
Other complications of internal prosthetic device, implant…	99675	T8585XA	Stenosis due to internal prosth dev/grft, NEC, init
Other complications of internal prosthetic device, implant…	99675	T8583XA	Hemorrhage due to internal prosth dev/grft, NEC, init
Other complications of internal prosthetic device, implant…	99675	T8584XA	Pain due to internal prosth dev/grft, NEC, init
Other complications of internal prosthetic device, implant…	99675	T8581XA	Embolism due to internal prosth dev/grft, NEC, init
Other complications of internal prosthetic device, implant…	99675	T8586XA	Thrombosis due to internal prosth dev/grft, NEC, init
Other complications of internal prosthetic device, implant…	99675	T8589XA	Oth complication of internal prosth dev/grft, NEC, init
Other complications of internal prosthetic device, implant…	99675	T8585XA	Stenosis due to internal prosth dev/grft, NEC, init
Other complications of internal prosthetic device, implant…	99675	T8584XA	Pain due to internal prosth dev/grft, NEC, init
Other complications of internal prosthetic device, implant…	99675	T8583XA	Hemorrhage due to internal prosth dev/grft, NEC, init
Other complications of internal prosthetic device, implant…	99675	T8582XA	Fibrosis due to internal prosth dev/grft, NEC, init

Other Conditions **ICD-9-CM Code Description**	**ICD-9-CM Code**	**ICD-10-CM Code**	**ICD-10-CM Code Description**
Other complications of internal prosthetic device, implant…	99675	T8581XA	Embolism due to internal prosth dev/grft, NEC, init
Presence of cerebrospinal fluid drainage device	V452	Z982	Presence of cerebrospinal fluid drainage device
Mucopolysaccharidosis (hydrocephalus and seizure)	2775	E763	Mucopolysaccharidosis, unspecified
Mucopolysaccharidosis (hydrocephalus and seizure)	2775	E761	Mucopolysaccharidosis, type II
Mucopolysaccharidosis (hydrocephalus and seizure)	2775	E7601	Hurler's syndrome
Mucopolysaccharidosis (hydrocephalus and seizure)	2775	E7629	Other mucopolysaccharidoses
Mucopolysaccharidosis (hydrocephalus and seizure)	2775	E7622	Sanfilippo mucopolysaccharidoses
Mucopolysaccharidosis (hydrocephalus and seizure)	2775	E7603	Scheie's syndrome
Mucopolysaccharidosis (hydrocephalus and seizure)	2775	E76219	Morquio mucopolysaccharidoses, unspecified
Encephalocele	7420	Q019	Encephalocele, unspecified
Absence part of brain, agenesis part of brain, agyria…	7422	Q041	Arhinencephaly
Absence part of brain, agenesis part of brain, agyria…	7422	Q042	Holoprosencephaly
Absence part of brain, agenesis part of brain, agyria…	7422	Q043	Other reduction deformities of brain
Congenital cerebral cyst, macrocephaly, etc	7424	Q045	Megalencephaly
Congenital cerebral cyst, macrocephaly, etc	7424	Q046	Congenital cerebral cysts
Congenital cerebral cyst, macrocephaly, etc	7424	Q048	Other specified congenital malformations of brain
Dwarfism, NOS	2594	E343	Short stature due to endocrine disorder
Achondroplastic dwarfism	7564	Q771	Thanatophoric short stature
Achondroplastic dwarfism	7564	Q778	Oth osteochndrdys w defct of growth of tublr bones and spine
Achondroplastic dwarfism	7564	Q784	Enchondromatosis
Achondroplastic dwarfism	7564	Q774	Achondroplasia
Spina bifida	7402	Q002	Iniencephaly
Spina bifida	7401	Q001	Craniorachischisis
Spina bifida	7400	Q000	Anencephaly
Anomalies of skull face bones. Includes craniosynostosis	7560	Q750	Craniosynostosis
Anomalies of skull face bones. Includes craniosynostosis	7560	Q752	Hypertelorism
Anomalies of skull face bones. Includes craniosynostosis	7560	Q759	Congenital malformation of skull and face bones, unspecified
Tuberous sclerosis	7595	Q851	Tuberous sclerosis
Cerebral cysts	3480	G930	Cerebral cysts
Encephalopathy, NEC	34831	G9341	Metabolic encephalopathy
Encephalopathy, NEC	34839	I6783	Posterior reversible encephalopathy syndrome
Encephalopathy, NEC	34839	G9349	Other encephalopathy
CNS complications from surgically implanted device	3491	G9782	Oth postproc complications and disorders of nervous sys
CNS complications from surgically implanted device	3491	G9782	Oth postproc complications and disorders of nervous sys
CNS complications from surgically implanted device	3491	G9782	Oth postproc complications and disorders of nervous sys
Hemangioma of unspecified site (includes	22802	D1802	Hemangioma of intracranial structures

Other Conditions ICD-9-CM Code Description	ICD-9-CM Code	ICD-10-CM Code	ICD-10-CM Code Description
cavernous malformation			
Phlebitis/thrombophlebitis of intracranial venous sinuses	325	G08	Intracranial and intraspinal phlebitis and thrombophlebitis
Occlusion and stenosis of basilar artery	43301	I6322	Cerebral infrc due to unsp occls or stenosis of basilar art
Occlusion and stenosis of basilar artery	43300	I651	Occlusion and stenosis of basilar artery
Occlusion and stenosis of carotid artery	43310	I6529	Occlusion and stenosis of unspecified carotid artery
Occlusion and stenosis of vertebral artery	43320	I6509	Occlusion and stenosis of unspecified vertebral artery
Occlusion and stenosis of precerebral arteries – multiple and bilateral	43330	I658	Occlusion and stenosis of other precerebral arteries
Occlusion and stenosis of precerebral arteries – other specified	43380	I658	Occlusion and stenosis of other precerebral arteries
Occlusion and stenosis of precerebral arteries - unspecified	43390	I659	Occlusion and stenosis of unspecified precerebral artery
Occlusion of the cerebral arteries – cerebral thrombosis	43400	I6609	Occlusion and stenosis of unspecified middle cerebral artery
Occlusion of the cerebral arteries – cerebral thrombosis	43400	I6619	Occlusion and stenosis of unsp anterior cerebral artery
Occlusion of the cerebral arteries – cerebral thrombosis	43400	I6629	Occlusion and stenosis of unsp posterior cerebral artery
Occlusion of the cerebral arteries – cerebral thrombosis	43400	I6629	Occlusion and stenosis of unsp posterior cerebral artery
Occlusion of the cerebral arteries – cerebral thrombosis	43400	I6619	Occlusion and stenosis of unsp anterior cerebral artery
Occlusion of the cerebral arteries – cerebral thrombosis	43400	I6609	Occlusion and stenosis of unspecified middle cerebral artery
Occlusion of the cerebral arteries – cerebral thrombosis	43401	I6330	Cerebral infarction due to thombos unsp cerebral artery
Occlusion of the cerebral arteries – cerebral thrombosis	43400	I6609	Occlusion and stenosis of unspecified middle cerebral artery
Occlusion of the cerebral arteries – cerebral thrombosis	43400	I6619	Occlusion and stenosis of unsp anterior cerebral artery
Occlusion of the cerebral arteries – cerebral thrombosis	43400	I6629	Occlusion and stenosis of unsp posterior cerebral artery
Occlusion of the cerebral arteries – cerebral embolism	43410	I6619	Occlusion and stenosis of unsp anterior cerebral artery
Occlusion of the cerebral arteries – cerebral embolism	43410	I6609	Occlusion and stenosis of unspecified middle cerebral artery
Occlusion of the cerebral arteries – cerebral embolism	43410	I669	Occlusion and stenosis of unspecified cerebral artery
Occlusion of the cerebral arteries – cerebral embolism	43410	I6629	Occlusion and stenosis of unsp posterior cerebral artery
Occlusion of the cerebral arteries – cerebral embolism	43411	I6340	Cerebral infarction due to embolism of unsp cerebral artery
Occlusion of the cerebral arteries – cerebral embolism	43410	I6619	Occlusion and stenosis of unsp anterior cerebral artery
Occlusion of the cerebral arteries – cerebral embolism	43410	I6609	Occlusion and stenosis of unspecified middle cerebral artery
Occlusion of the cerebral arteries – cerebral embolism	43410	I6629	Occlusion and stenosis of unsp posterior cerebral artery
Occlusion of the cerebral arteries – cerebral embolism	43410	I669	Occlusion and stenosis of unspecified cerebral artery
Occlusion of the cerebral arteries – cerebral embolism	43410	I6619	Occlusion and stenosis of unsp anterior cerebral artery
Occlusion of the cerebral arteries – cerebral embolism	43410	I6629	Occlusion and stenosis of unsp posterior cerebral artery
Occlusion of the cerebral arteries – cerebral embolism	43410	I6609	Occlusion and stenosis of unspecified middle cerebral artery
Occlusion of the cerebral arteries – cerebral artery occlusion	43491	I6350	Cereb infrc due to unsp occls or stenos of unsp cereb artery
Occlusion of the cerebral arteries – cerebral artery occlusion	43490	I669	Occlusion and stenosis of unspecified cerebral artery

Other Conditions ICD-9-CM Code Description	ICD-9-CM Code	ICD-10-CM Code	ICD-10-CM Code Description
Occlusion of the cerebral arteries – cerebral artery occlusion	43490	I669	Occlusion and stenosis of unspecified cerebral artery
Transient cerebral ischemia – basilar/vertebral artery syndrome, etc	4359	I67848	Other cerebrovascular vasospasm and vasoconstriction
Transient cerebral ischemia – basilar/vertebral artery syndrome, etc	4359	G459	Transient cerebral ischemic attack, unspecified
Transient cerebral ischemia – basilar/vertebral artery syndrome, etc	4352	G458	Oth transient cerebral ischemic attacks and related synd
Transient cerebral ischemia – basilar/vertebral artery syndrome, etc	4358	G458	Oth transient cerebral ischemic attacks and related synd
Transient cerebral ischemia – basilar/vertebral artery syndrome, etc	4358	G451	Carotid artery syndrome (hemispheric)
Transient cerebral ischemia – basilar/vertebral artery syndrome, etc	4351	G450	Vertebro-basilar artery syndrome
Transient cerebral ischemia – basilar/vertebral artery syndrome, etc	4353	G450	Vertebro-basilar artery syndrome
Transient cerebral ischemia – basilar/vertebral artery syndrome, etc	4350	G450	Vertebro-basilar artery syndrome
Transient cerebral ischemia – basilar/vertebral artery syndrome, etc	4358	G458	Oth transient cerebral ischemic attacks and related synd
Transient cerebral ischemia – basilar/vertebral artery syndrome, etc	4352	G458	Oth transient cerebral ischemic attacks and related synd
Transient cerebral ischemia – basilar/vertebral artery syndrome, etc	4350	G450	Vertebro-basilar artery syndrome
Transient cerebral ischemia – basilar/vertebral artery syndrome, etc	4351	G450	Vertebro-basilar artery syndrome
Transient cerebral ischemia – basilar/vertebral artery syndrome, etc	4353	G450	Vertebro-basilar artery syndrome
Transient cerebral ischemia – basilar/vertebral artery syndrome, etc	4350	G450	Vertebro-basilar artery syndrome
Transient cerebral ischemia – basilar/vertebral artery syndrome, etc	4351	G450	Vertebro-basilar artery syndrome
Transient cerebral ischemia – basilar/vertebral artery syndrome, etc	4353	G450	Vertebro-basilar artery syndrome
Cerebral aneurysm, nonruptured	4373	I671	Cerebral aneurysm, nonruptured
Moyamoya disease	4375	I675	Moyamoya disease
Nonpyogenic thrombosis of intracranial venous sinus	4376	I676	Nonpyogenic thrombosis of intracranial venous system
Other congenital anomalies of circulatory system – coartcation of the aorta	74710	Q251	Coarctation of aorta
Other congenital anomalies of circulatory system – other anomalies of the aorta	74721	Q254	Other congenital malformations of aorta
Other congenital anomalies of circulatory system – other anomalies of the aorta	74720	Q254	Other congenital malformations of aorta
Other congenital anomalies of circulatory system – other anomalies of the aorta	74729	Q254	Other congenital malformations of aorta
Other congenital anomalies of circulatory system – other anomalies of the aorta	74722	Q253	Supravalvular aortic stenosis
Other congenital anomalies of circulatory system – other anomalies of the aorta	74722	Q252	Atresia of aorta
Other congenital anomalies of circulatory system – other anomalies of the aorta	74721	Q254	Other congenital malformations of aorta
Other congenital anomalies of circulatory system – other anomalies of the aorta	74729	Q254	Other congenital malformations of aorta
Other congenital anomalies of circulatory system – other anomalies of the aorta	74720	Q254	Other congenital malformations of aorta
Other congenital anomalies of circulatory system – other anomalies of the aorta	74729	Q254	Other congenital malformations of aorta
Other congenital anomalies of circulatory system – other anomalies of the aorta	74720	Q254	Other congenital malformations of aorta
Other congenital anomalies of circulatory system – other anomalies of the aorta	74721	Q254	Other congenital malformations of aorta
Other specified anomalies of circulatory system (includes anteriovenous malformation) – cerebrovascular	74781	Q283	Other malformations of cerebral vessels

Other Conditions ICD-9-CM Code Description	ICD-9-CM Code	ICD-10-CM Code	ICD-10-CM Code Description
Other specified anomalies of circulatory system (includes anteriovenous malformation) – cerebrovascular	74781	Q282	Arteriovenous malformation of cerebral vessels
Other specified anomalies of circulatory system (includes anteriovenous malformation)	74789	Q288	Oth congenital malformations of circulatory system
Other venous embolism/thrombosis unspecified site	7539	Q649	Congenital malformation of urinary system, unspecified
Other and unspecified intracranial hemorrhage	4329	I629	Nontraumatic intracranial hemorrhage, unspecified
Other and unspecified intracranial hemorrhage	4321	I6200	Nontraumatic subdural hemorrhage, unspecified
Other and unspecified intracranial hemorrhage	4320	I621	Nontraumatic extradural hemorrhage
Personal history of other certain diseases – TIA and cerebral infarction	V1250	Z8679	Personal history of other diseases of the circulatory system
Personal history of other certain diseases – TIA and cerebral infarction	V1250	Z8679	Personal history of other diseases of the circulatory system

Chart Abstraction Tool

Overuse of Imaging for the Evaluation of Children with Post-Traumatic Headache

1. Date and time of ED visit with imaging

___/___/_____ ___:___

2a. Documentation of trauma

☐Yes ☐No

2b. Time of trauma within 24 hours

Mark yes if "yesterday" is all that is mentioned, without note of the exact time.

☐Yes ☐No → If "No" exclude from denominator and STOP.

2c. Was there documentation of a specific time of trauma?

☐Yes ☐No

2d. Date and time of trauma

___/___/_____ ___:___

3a. Was the case included based only on the presence of the ICD-9-CM code for headache (7840)?

☐Yes ☐No

3b. If yes – Was there clinical documentation of trauma (per Item 2a)?

☐Yes ☐No → If "No" exclude from denominator and STOP.

4a. Was the case included based only on the presence of the ICD-9-CM code for concussion (8500)?

☐Yes ☐No

4b. If yes – Was there clinical documentation of headache as a symptom?

☐Yes ☐No → If "No" exclude from denominator and STOP.

5. Was there documentation of suspected child abuse of neglect in the notes from the ED visit during which neuroimaging was obtained?

☐Yes ☐No → If "Yes" exclude from denominator and STOP.

6. Was there documentation of history of a medical condition* that could otherwise warrant imaging in the notes from the ED visit during which neuroimaging was obtained?

☐Yes ☐No→ If "Yes" exclude from denominator and STOP.

**Mark "Yes" for medical conditions such as neoplasm and blood disorder, hydrocephalus and CNS anomalies, tuberous sclerosis, dwarfism, hemangioma, phlebitis/thrombophlebitis, intracranial hemorrhage, occlusion of cerebral arteries, moyamoya disease, congenital heart disease, anticoagulation.*

Was there documentation of a severe mechanism of injury?

Mark “Yes” for mechanisms of injury such as penetrating trauma, fall from more than 5 feet, pedestrian struck by vehicle.

☐Yes ☐No → If “Yes” exclude from numerator.

Was there documentation of seizure or convulsion associated with trauma?

☐Yes ☐No → If “Yes” exclude from numerator.

Was there documentation of loss of consciousness associated with trauma?

☐Yes ☐No → If “Yes” exclude from numerator.

Was there documentation of repeated vomiting?

☐Yes ☐No → If “Yes” exclude from numerator.

Was there documentation of basilar skull fracture?

☐Yes ☐No → If “Yes” exclude from numerator.

Was there documentation of signs of basilar skull fracture?

Mark “Yes” if the following physical examination findings are documented: “Raccoon eyes” (bruising around the eyes/black eyes), Battle’s sign (bruising behind one or both ears), hemotympanum (blood behind one or both ear drums).

☐Yes ☐No → If “Yes” exclude from numerator.

Was there documentation of a neurologic examination?

☐Yes ☐No → If “Yes” exclude from numerator.

Was there documentation of an abnormal neurologic examination, signs and symptoms of intracranial hemorrhage or increased intracranial pressure?

Mark “Yes” if any of the examination findings, signs or symptoms listed below were present in the clinical documentation.

☐Yes ☐No → If “Yes” exclude from numerator.

Decreased alertness, confusion, not acting like himself/herself?
☐Yes ☐No
Altered mental status
☐Yes ☐No
Glasgow Coma Scale Score <14
☐Yes ☐No
Papilledema
☐Yes ☐No
Diplopia
☐Yes ☐No
Abnormal face or eye movements
☐Yes ☐No
Asymmetric face or extremity muscle movements
☐Yes ☐No
Alerted sensation
☐Yes ☐No
Dizziness
☐Yes ☐No
Gait disturbance
☐Yes ☐No
Lack of coordination
☐Yes ☐No