Prepared for:

Centers for Medicare & Medicaid Services

CMS Alliance to Modernize Healthcare
Federally Funded Research and Development Center

FFRDC Project Title: Health Technology Assessments

Task Order No. 019

Claims Data Analysis to Define Priority Clinical Areas for Advanced Imaging

Final Report

Version 1

May 20, 2016

Report Authors
CMS Alliance to Modernize Healthcare

Susan W. Fan, MD, The ACI Group

Lionel M. Levine, The MITRE Corporation

Brooke A. Eckman, The MITRE Corporation

Colleen B. Pelser, The MITRE Corporation

Carmen M. Cunningham, HealthCare Dynamics International (HCDI)

Robert L. Chiteman, MD, The ACI Group

Juan Arroyo, PhD, The MITRE Corporation

About the CMS Alliance to Modernize Healthcare

The Centers for Medicare & Medicaid Services (CMS) sponsors the CMS Alliance to Modernize Healthcare (CAMH), the first Federally Funded Research and Development Center (FFRDC) dedicated to strengthening our nation's healthcare system.

The CAMH FFRDC enables CMS, the Department of Health and Human Services (HHS), and other government entities to access unbiased research, advice, guidance, and analysis to solve complex business, policy, technology, and operational challenges in health mission areas. The FFRDC objectively analyzes long-term health system problems, addresses complex technical questions, and generates creative and cost-effective solutions in strategic areas such as quality of care, new payment models, and business transformation.

Formally established under Federal Acquisition Regulation (FAR) Part 35.017, FFRDCs meet special, long-term research and development needs integral to the mission of the sponsoring agency—work that existing in-house or commercial contractor resources cannot fulfill as effectively. FFRDCs operate in the public interest, free from conflicts of interest, and are managed and/or administered by not-for-profit organizations, universities, or industrial firms as separate operating units.

The CAMH FFRDC applies a combination of large-scale enterprise systems engineering and specialized health subject matter expertise to achieve the strategic objectives of CMS, HHS, and other government organizations charged with health-related missions. As a trusted, not-for-profit adviser, the CAMH FFRDC has access, beyond what is allowed in normal contractual relationships, to government and supplier data, including sensitive and proprietary data, and to employees and government facilities and equipment that support health missions.

CMS conducted a competitive acquisition in 2012 and awarded the CAMH FFRDC contract to The MITRE Corporation (MITRE). MITRE operates the CAMH FFRDC in partnership with CMS and HHS, and maintains a collaborative alliance of partners from nonprofits, academia, and industry. This alliance provides specialized expertise, health capabilities, and innovative solutions to transform delivery of the nation's healthcare services. Government organizations and other entities have ready access to this network of partners, including RAND Health, the Brookings Institution, and other leading healthcare organizations. This includes select qualified small and disadvantaged business.

The FFRDC is open to all CMS and HHS Operating Divisions and Staff Divisions. In addition, government entities outside of CMS and HHS can use the FFRDC with permission of CMS, CAMH's primary sponsor.

Executive Summary

The Centers for Medicare & Medicaid Services (CMS), through its Coverage and Analysis Group, engaged the CMS Alliance to Modernize Healthcare (CAMH) Federally Funded Research and Development Center (FFRDC) to begin developing efficient and effective processes for managing current and future health technology assessments. This supports CMS's efforts to enhance access to reasonable and necessary technologies and services for beneficiaries that improve health outcomes, while safeguarding them from potential harms associated with technologies and services that are of questionable value and not proven to improve their health outcomes. CMS relies on this CAMH FFRDC expertise and objectivity to conduct technology assessments that serve only the interests of the government and its beneficiary population. CAMH leveraged its Alliance Partners to bring together the expertise needed to prepare this technical report.

This report presents a summary of findings from claims data from the Medicare population and their utilization of advanced imaging procedures. This report will serve, in part, to help CMS establish priority clinical areas for the Medicare-appropriate use criteria program for advanced diagnostic imaging services. The analysis presented in this report is a cross-walk on claims data only, derived from the Chronic Condition Data Warehouse (CCW)'s 2014 Part B non-institutional claim line file. Starting with Healthcare Common Procedure Coding System (HCPCS) advanced imaging procedure codes from Medicare claims, the CAMH team identified the main diagnoses that emerged by volume of instances and used these to establish diagnosis groups. Those groupings allowed the CAMH team to correlate diagnoses to the most common procedures used in 2014. From this, it was surmised how the grouped diagnosis and attendant imaging workup related to everyday practice in terms of disease prevalence.

The CAMH team's analysis did not consider information found in the patient's medical record and did not have insight on the patient's medical history or their clinical outcomes after imaging. The picture that emerged, in terms of common diagnoses for the population receiving Medicare, is that advanced imaging procedures were reasonably matched to the grouped diagnosis codes the team developed, and the corresponding imaging modalities used to investigate them. This analysis to correlate imaging procedure codes with diagnoses groups derived from claims data pointed to the following as clinical areas to prioritize based on the frequency of occurrence: heart condition, back and neck pain, acute abdominal pain, malignancies, headache and/or head injury, stroke symptoms, pulmonary abnormalities, face and neck injury, and altered mental status.

Table of Contents

List of Charts

List of Tables

1. Introduction

The Centers for Medicare & Medicaid Services (CMS), through its Coverage and Analysis Group, engaged the CMS Alliance to Modernize Healthcare (CAMH) Federally Funded Research and Development Center (FFRDC) to begin developing efficient and effective processes for managing current and future health technology assessments. To this end, Task Order 19, Health Technology Assessments (HTAs), was awarded to provide CMS access to timely and accurate health technology assessments that support national coverage determinations and other Medicare policies. The HTA project aligns to CMS's strategic objectives to expand coverage and to improve quality of care. It supports CMS's efforts to enhance access to reasonable and necessary technologies and services for beneficiaries that improve health outcomes, while safeguarding them from potential harms associated with technologies and services that are of questionable value and not proven to improve health outcomes.

The CAMH FFRDC operator provides CMS access to personnel with the breadth and depth of skill sets needed who are devoid of any potential conflict of interest to ensure that technical assessments remain free of intellectual and economic conflicts of interest. CMS relies on this CAMH FFRDC expertise and objectivity to conduct technology assessments that serve only the interests of the government and its beneficiary population. CAMH leveraged its Alliance Partners to bring together the expertise needed to prepare this technical report.

To help CMS establish priority clinical areas for the Medicare-appropriate use criteria program for advanced diagnostic imaging services, CAMH was asked to undertake an analysis of claims data from the Medicare population and their utilization of advanced imaging procedures. This report presents a summary of findings from the analysis. The data analysis began by first looking at the information from the perspective of the patient presenting to the physician's office with a chief complaint; this would register in our data as an International Classification of Diseases (ICD)-9 diagnosis code. The analysis was worked backwards from the ICD-9 diagnostic codes to group the complaints into categories based on similarities known from previous imaging workup on patients. For example, the CAMH team realized from preliminary analyses that the chief complaint of headache or head injury was associated with a computed tomography (CT) scan of the head 85-95% of the time, so this became a diagnostic group. Additional details on the methodology for the report are provided in the Methods section (Section 2).

The analysis presented in this report is a cross-walk on claims data only. Starting with all advanced imaging procedure codes from Medicare claims from 2014, the CAMH team identified the main diagnoses that emerged by volume of instances and used these to establish diagnosis groups. Those groupings allowed the CAMH team to correlate diagnoses to the most common procedures used in 2014. From this, we surmised how the grouped diagnosis and attendant imaging workup related to everyday practice in terms of disease prevalence.

The CAMH team's analysis did not consider information found in the patients' medical record and did not have insight on the patient's medical history or their clinical outcomes after imaging; however, the picture that emerged, in terms of common diagnoses for the population receiving Medicare, is that advanced imaging procedures were reasonably matched to the grouped diagnosis codes the team developed, and the corresponding imaging modalities used to investigate them.

2. Methods

The primary data source for this analysis is CMS's Chronic Conditions Data Warehouse (CCW). The CCW contains 100 percent of Medicare claims for beneficiaries who are enrolled in the fee-for-service (FFS) program.

Data was derived from the CCW's 2014 Part B non-institutional claim line file, which includes services covered by the Part B benefit that were furnished during calendar year 2014. This is the main file containing final action claims data for non-institutional providers including physicians, physician assistants, clinical social workers, nurse practitioners, independent clinical laboratories, and freestanding ambulatory surgical centers. This data was provided to MITRE by CMS.

The Part B non-institutional claim line file contains the individual line level information from the claim and includes Healthcare Common Procedure Coding System (HCPCS) code(s), ICD-9 diagnosis code(s), service dates, and line Medicare payment amount. The analysis focused on non-institutional claims data for a group of advanced imaging HCPCS codes provided by the CMS.

A given imaging service can appear in multiple lines within the claim line file. In order to avoid counting a single service more than once, claim lines with the same beneficiary identifier, HCPCS code, and service date, were combined into a single record.

The analysis provides a cross-tabulation of diagnosis codes and HCPCS codes. A non-institutional claim can have up to 25 diagnosis codes. This analysis used the Line Diagnosis Code variable, which is the diagnosis code that supports the procedure on the claim.

For each HCPCS code, the Service variable indicates the total sum of unduplicated services, advanced imaging procedures, furnished by non-institutional providers that had the indicated line diagnosis code. The corresponding Payment variable indicates the total Medicare payments made to non-institutional providers for those services.

The CAMH team used the aggregated Part B non-institutional claims data from 2014 to find the top (most frequent) diagnoses and associated procedures. The analysis was limited to claims from 2014; however, a comparative analysis was completed for 2013 data to ensure the inclusion of the top diagnoses from that year as well.

To best identify the potential clinical priority areas within the total count of 37,970,845 claims, the CAMH team limited the results to the top 20 diagnoses in 2014 as determined by the total count of each individual diagnosis provided in Part B non-institutional claims data. The list of top diagnoses included the top 20 diagnoses from 2014 with the addition of three diagnoses. The added diagnoses, 437.1 – Other generalized ischemic cerebrovascular disease, 592.00 – Calculus of kidney, and 562.10 – Diverticulosis of colon (without mention of hemorrhage), were found in the top 20 diagnoses for 2013, but were ranked 23, 25, and 28, respectively, in 2014.

Due to condition similarities among the top 20 diagnoses, the CAMH team generated specific, or focused, diagnoses groups by clustering individual ICD-9 codes into broader diagnostic groupings. The top 20 diagnoses results were grouped into the following categories, based on condition similarities:

- Heart condition

- Headache and/or head injury
- Acute abdominal pain
- Stroke symptoms
- Low back pain
- Pulmonary abnormal[1]

The remaining top diagnoses as determined by count: 185.00 - Malignant neoplasm of prostate, 78097 – Altered mental status, 162.9 – Malignant neoplasm of bronchus and lung, unspecified, 959.09 – Injury of face and neck, and 511.9 – Unspecified pleural effusion, were not grouped and remained as individual diagnoses for the analysis. The ICD-9 codes were grouped based on similarity to represent the progression from examination and testing to diagnosis. The total number of diagnoses for each broader diagnostic grouping was found by calculating the sum of each diagnosis within the group.

To support these findings, the CAMH team also examined the diagnoses list beyond the top 20 to test if diagnoses with a frequency between 90,000 and 300,000 were enough to create new categories. As a result of this second assessment, we grouped all malignancies into one diagnosis category and added neck pain to the low back pain category.

During both assessments (top 20 diagnoses and beyond top 20), after the diagnoses were grouped, the CAMH team found the top five procedures for each diagnosis group by ranking the procedures based on number of procedures performed. Procedures: Q9966 Low osmolar contrast material, 200-299 milligrams (mg)/milliliters (ml) iodine concentration per ml; Q9967 Low osmolar contrast material, 300-399 mg/ml iodine concentration per ml; and A9579 Injection, gadolinium-based magnetic resonance contrast agent, not otherwise specified per ml, were also removed as they are not a procedure and only describe the material used for contrast.

Wherever possible, the procedures were grouped based on similarities of the imaging used. This was done in order to better illustrate the types of imaging procedures used for the diagnoses analyzed. The total number of services for the grouped procedures was done by calculating the sum of each procedure within the group.

The following list shows how grouped procedures were categorized (if needed) to generate the procedures breakdown pie charts:

- Cardiology Stress Testing:
    - 93018 Cardiology stress testing with interpretation & report only
    - 93016 Cardiology stress testing with physician without interpretation & reporting
    - 93015 Cardiology stress testing
- Magnetic Resonance Imaging (MRI) Brain:

[1] Pulmonary abnormal is a pre-diagnosis condition grouping comprised of codes indicating an initial abnormal finding that will likely be revised into a firm diagnosis subject to additional testing.

  - 70551 MRI brain; non contrast
  - 70553 MRI brain; with & without contrast
- CT Scan Abdomen and Pelvis:
  - 74176 CT scan, abdomen and pelvis; without contrast material
  - 74177 CT scan, abdomen and pelvis; with contrast material(s)
  - 74178 CT scan, abdomen and pelvis; without contrast material in one or both bodies
- MRI Lumbar:
  - 72148 MRI lumbar spine; non contrast
  - 72158 MRI lumbar spine; with & without contrast
- CT Scan Lumbar:
  - 72131 CT scan, lumbar spine; without contrast material
  - 72132 CT scan, lumbar spine; with contrast material
- CT Scan Thorax:
  - 71250 CT scan, thorax; without contrast material
  - 71260 CT scan, thorax; with contrast material(s)
- CT Scan Head or Brain:
  - 70450 CT scan, head or brain; without contrast material
  - 70470 CT scan, head or brain; without contrast, followed by contrast

3. Results

This section presents preliminary findings and recommendations from an analysis conducted on the subset of total Medicare non-institutional claims data with relevant imaging HCPCS codes provided by CMS for imaging services rendered during 2014.

Table 1 reflects the top 20 diagnoses, by frequency, associated with advanced imaging procedures for Medicare beneficiaries in 2014. The total number shows the frequency of these top diagnosis in descending order. The CAMH team opted to first examine the top 20 diagnoses by frequency under the assumption that it would allow us to establish the main categories of patient's complaints during a doctor's visit. Although the team did not have the ordering physician's claim data available, they extrapolated from the furnishing physician's claim the original patient's complaint based on the association between the imaging procedure and the diagnosis code on the furnishing physician's claim. For example, if the furnishing physician's claim was for a low back pain diagnosis and lumbar MRI was the common modality in those claims, it was assumed the patient presented low back pain during the initial doctor's visit.

Table 1. Medicare 2014 Top Diagnoses by Frequency

Ranking	Diagnosis	Count
1	786.50 - Chest pain NOS	2,073,830
2	784.00 - Headache	962,247
3	789.00 - Abdominal pain unspecified site	953,023
4	414.01 - CORONARY ATHEROSCLEROSIS OF NATIVE CORONARY ARTERY	911,117
5	786.05 - Shortness of breath	880,408
6	185.00 - MALIGNANT NEOPLASM OF PROSTATE	877,637
7	959.01 - Head injury NOS	785,735
8	780.97 - Altered mental status	674,437
9	434.91 - CEREBRAL ARTERY OCCLUSION UNSPECIFIED WITH CEREBRAL INFARCTION	585,554
10	780.4 - Dizziness and giddiness	532,386
11	162.9 - MALIGNANT NEOPLASM OF BRONCHUS AND LUNG UNSPECIFIED	510,519
12	794.31 - NONSPECIFIC ABNORMAL ELECTROCARDIOGRAM (ECG) (EKG)	505,852
13	414.00 - CORONARY ATHEROSCLEROSIS OF UNSPECIFIED TYPE OF VESSEL NATIVE OR GRAFT	461,459
14	793.19 - OTHER NONSPECIFIC ABNORMAL FINDING OF LUNG FIELD	455,388
15	722.10 - Lumbar disc displacement	445,200
16	959.09 - Face & neck injury	359,886
17	780.2 - Syncope and collapse	350,693
18	722.52 - DEGENERATION OF LUMBAR OR LUMBOSACRAL INTERVERTEBRAL DISC	348,407
19	511.9 - Pleural effusion NOS	348,286
20	793.11 - Solitary pulmonry nodule	347,034
23	437.1 - OTHER GENERALIZED ISCHEMIC CEREBROVASCULAR DISEASE	308,800
25	592.00 - Calculus of kidney	296,366
28	562.10 - DIVERTICULOSIS OF COLON (WITHOUT HEMORRHAGE)	290,055

Although the CAMH team limited our analysis to 2014 data, to better contextualize these findings temporally, a brief comparative assessment was run on 2013 data. Three diagnoses in the top 20 of 2013 did not carry over into 2014. These were included in our count (numbers 23, 25, and 28 in Table 1) since they belong in the group created for Acute Abdominal conditions.

Each row presents the diagnosis with its formal name and associated ICD-9 code, along with the total number of instances it appeared on the claims data analyzed. This indicated the number of instances the diagnosis was associated with an advanced imaging procedure on a claim submitted to Medicare in 2014.

The CAMH team generated specific, or focused, diagnoses groups by clustering individual ICD-9 codes into broader condition groupings and color coded them accordingly. For instance, "786.50 – Chest pain NOS"[2] belongs to the diagnoses group *Heart condition* to allow for additional analysis based on larger diagnoses or condition groups.

Table 2 takes those 23 top diagnoses and sorts them into the broader condition groups and color codes them, (color coding is consistent across the report).

[2] NOS is Not Otherwise Specified.

Table 2. Medicare 2014 Top Diagnoses by Frequency Sorted into Condition Groups

Ranking	Condition Group	Diagnosis	Count
1	Heart Condition	786.50 - Chest pain NOS	2,073,830
4		414.01 - CORONARY ATHEROSCLEROSIS OF NATIVE CORONARY ARTERY	911,117
5		786.05 - Shortness of breath	880,408
12		794.31 - NONSPECIFIC ABNORMAL ELECTROCARDIOGRAM (ECG) (EKG)	505,852
13		414.00 - CORONARY ATHEROSCLEROSIS OF UNSPECIFIED TYPE OF VESSEL NATIVE OR GRAFT	461,459
2	Headache and/or Head injury	784.00 - Headache	962,247
7		959.01 - Head injury NOS	785,735
10		780.4 - Dizziness and giddiness	532,386
3	Acute abdominal pain	789.00 - Abdominal pain unspecified site	953,023
25		592.00 - Calculus of kidney	296,366
		562.10 - DIVERTICULOSIS OF COLON (WITHOUT HEMORRHAGE)	290,055
9	Stroke symptoms	434.91 - CEREBRAL ARTERY OCCLUSION UNSPECIFIED WITH CEREBRAL INFARCTION	585,554
17		780.2 - Syncope and collapse	350,693
23		437.1 - OTHER GENERALIZED ISCHEMIC CEREBROVASCULAR DISEASE	308,800
6	Malignant neoplasm of prostate	185.00 - MALIGNANT NEOPLASM OF PROSTATE	877,637
14	Pulmonary abnormal	793.19 - OTHER NONSPECIFIC ABNORMAL FINDING OF LUNG FIELD	455,388
20		793.11 - Solitary pulmonry nodule	347,034
15	Low back pain	722.10 - Lumbar disc displacement	445,200
18		722.52 - DEGENERATION OF LUMBAR OR LUMBOSACRAL INTERVERTEBRAL DISC	348,407
8	Altered mental status	780.97 - Altered mental status	674,437
11	Malignant neoplasm of bronchus/lung NOS	162.9 - MALIGNANT NEOPLASM OF BRONCHUS AND LUNG UNSPECIFIED	510,519
16	Face & neck injury	959.09 - Face & neck injury	359,886
19	Pleural effusion	511.9 - Pleural effusion NOS	348,286

The cumulative total of the number of diagnoses associated with advanced imaging ordering for each of the monitored condition groups is shown in Table 3. The groups were labeled as follows: *Heart condition*, *Headache and/or Head injury*, *Acute abdominal pain*, *Stroke symptoms*, *Pulmonary abnormal*, and *Low back pain*. The following 5 diagnoses were not grouped and remained standalone diagnoses with significant counts in 2014: 185.00 – Malignant neoplasm of prostate, 780.97– Altered mental status, 162.9 – Malignant neoplasm of bronchus and lung unspecified, 959.09 – Face and neck injury, and 511.9 - Pleural effusion NOS.

Table 3. Condition Grouping Totals

Grouping Total Diagnoses	Count
Heart condition	4,832,666
Headache and/or Head injury	2,280,368
Acute abdominal pain	1,539,444
Stroke symptoms	1,245,047
Malignant neoplasm of the prostate	877,637
Pulmonary abnormal	802,422
Low back pain	793,607
Altered mental status	674,437
Malignant neoplasm of bronchus/lung NOS	510,519
Face & neck injury	359,886
Pleural effusion NOS	348,286

The rationale for grouping similar ICD-9 codes was to simulate the natural progression of a patient presenting to the physician with a complaint, and the complaint being worked up by history, physical exam, laboratory testing, and imaging, thereby reaching a diagnosis based on the complete workup.

In one scenario, a patient might present with acute abdominal pain, for example, and the physical exam might indicate pain localized to the left lower quadrant. Blood work would show an elevated white blood cell count with a left shift, and a CT scan of the abdomen would demonstrate that the cause of the presenting symptom is actually acute diverticulitis. Similarly, complaints of acute abdominal pain might be shown to represent appendicitis, ischemic colitis, or bowel obstruction, following the same clinical algorithm. Therefore, the CAMH team elected to group the top causes of acute abdominal pain together since the workup and presentation are very similar.

This grouping model works well for the other categories, such as *Heart condition*, where a similar investigative protocol results in the diagnosis of multiple related conditions, such as coronary artery ischemic attack, heart failure, or angina.

The purpose of grouping similar diagnoses was to demonstrate that not only are they alike in symptomatology, but the modes of imaging investigation also correlate. For example, in the grouped diagnosis A*cute abdominal pain*, this includes such diagnostic codes as acute diverticulitis, kidney stone, and bowel obstruction. All of these conditions will present with abdominal pain, and nearly all of the patients received a CT scan. In many cases, the CT results either determined the actual cause of nonspecific complaints, or confirmed the suspected cause, such as acute appendicitis.

The largest category of grouped diagnoses, *Heart condition*, deserves further discussion. This designation includes the diagnosis codes for chest pain, coronary artery atherosclerosis of the native vessel or graft, shortness of breath, and abnormal electrocardiogram in descending order of frequency. As shown in Chart 1, procedure codes frequency reflects the significance of the high prevalence of heart disease in the Medicare population, with over four million exams performed for this grouped diagnosis.

Chart 1 presents the condition grouping totals table in graph form. The total number of diagnosis instances associated with advanced imaging of each condition group is presented, allowing us to better compare relative sizes of the groups.

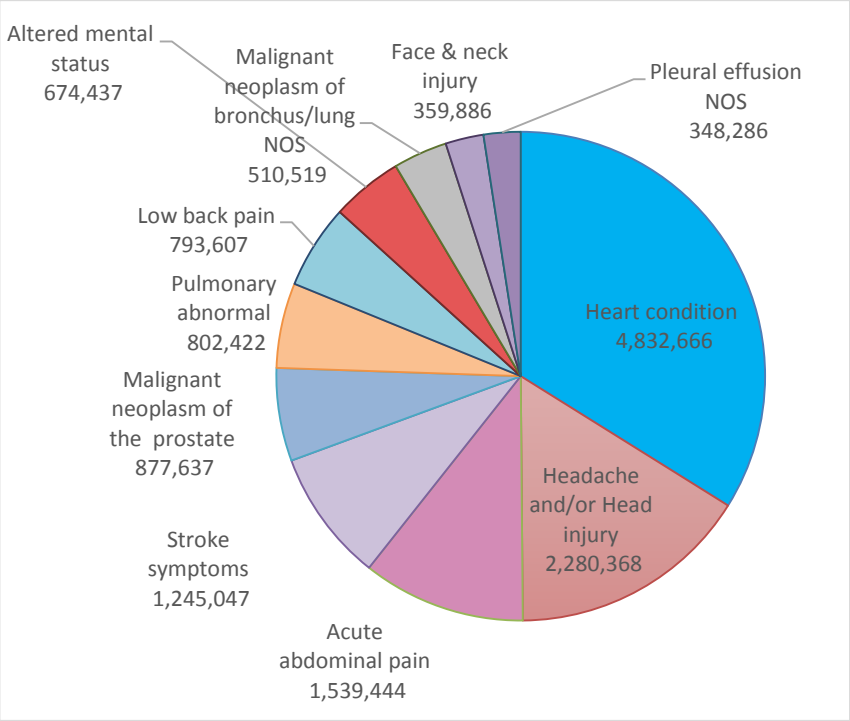


Chart 1. Cumulative Total of Top-20 Diagnoses Clustered into Condition Groups

Please note that the combined group *Heart condition* represents about one third of all imaging-related diagnoses of the top diagnoses analyzed. This was expected since heart disease is the number one cause of death in America, and particularly the Medicare aged population [1]. Also of interest, the categories *Headache and/or Head injury*, *Altered mental status*, and *Stroke symptoms* (all of which are associated with CT scan of the head), together represent another 1/3 of imaging-related diagnoses. The association between this last set of complaints and the rapidly increasing number of elderly patients with Alzheimer's disease may be worth further exploration.

To put these diagnoses numbers into better context, Chart 2 shows the overall percentages of the condition groups in the context of total advanced imaging procedures ordered. Of note is that only 38% of all conditions analyzed are in the top 20.

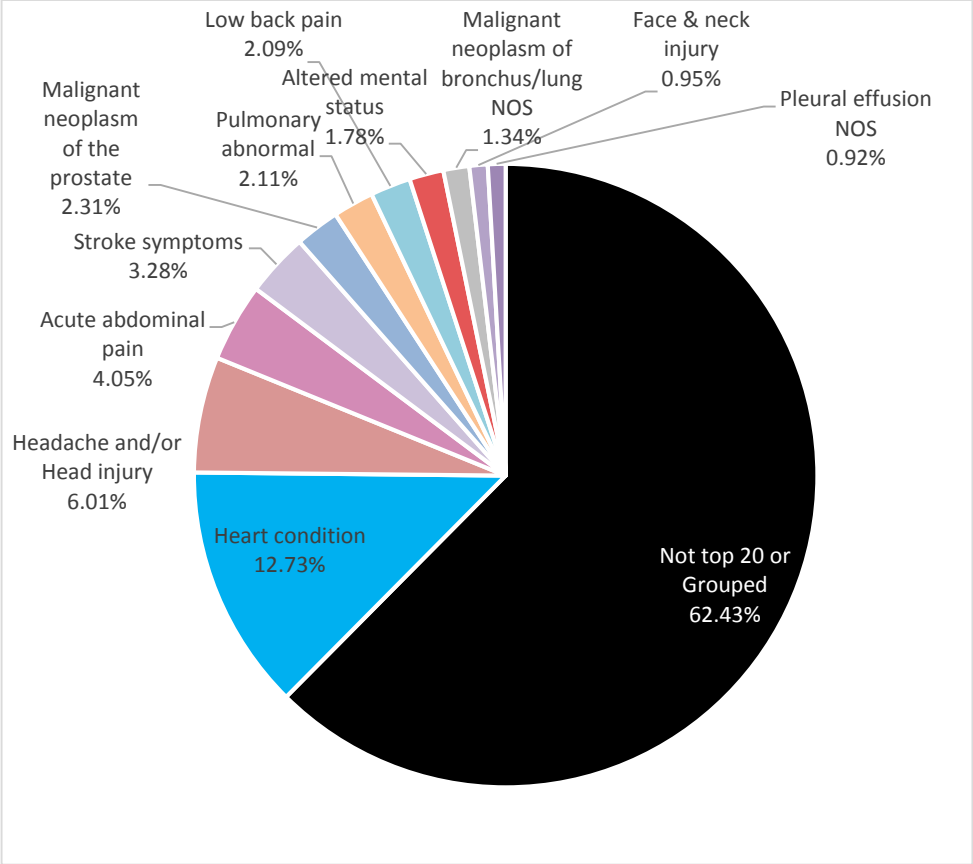


Chart 2. Condition Group Diagnoses Percentage in Relation to Total Number of Diagnoses

When the CAMH team examined the pie chart depicting the top condition group percentages among the overall number of diagnoses associated with advanced imaging procedures, we recognized that 62% of the diagnoses were not grouped (see Chart 2). Because this non-grouped set of diagnoses was so large, the CAMH team needed to further analyze it. We discovered that reviewing the diagnoses occurring in frequency from 300,000 down to about 90,000 instances, we were able to further characterize many of these diagnoses into our original eleven diagnosis groups, reducing it to ten groups by combining all forms of malignancy. The team also added neck pain to the existing *Low back pain* category. In this way, we were able to reduce the 62% of diagnoses not grouped to 33% (see Chart 3). For diagnoses that occurred less than 100,000 times, we did not go through the exercise, as these are likely to be less statistically significant given their small numbers.

Table 4 shows how the diagnoses groups were expanded by adding diagnoses occurring less than 300,000 instances or count. New categories of diagnoses with lower counts were also included in this table.

Table 4. Top Expanded Diagnoses by Frequency Sorted into Condition Groups

Condition Group	Diagnoses (over 90,000 instances)	Count
Heart condition	786.50 - Chest pain NOS	2,073,830
	414.01 - CORONARY ATHEROSCLEROSIS OF NATIVE CORONARY ARTERY	911,117
	786.05 - Shortness of breath	880,408
	794.31 - NONSPECIFIC ABNORMAL ELECTROCARDIOGRAM (ECG) (EKG)	505,852
	414.00 - CORONARY ATHEROSCLEROSIS OF UNSPECIFIED TYPE OF VESSEL NATIVE OR GRAFT	461,459
	413.9 - OTHER AND UNSPECIFIED ANGINA PECTORIS	294,705
	786.59 - OTHER CHEST PAIN	294,184
	427.31 - Atrial fibrillation	195,250
	786.51 - Precordial pain	186,871
	V72.81 - PRE-OPERATIVE CARDIOVASCULAR EXAMINATION	101,486
Low back & neck pain	722.10 - Lumbar disc displacement	445,200
	722.52 - DEGENERATION OF LUMBAR OR LUMBOSACRAL INTERVERTEBRAL DISC	348,407
	724.2 - Lumbago	314,838
	724.02 - SPINAL STENOSIS, LUMBAR REGION, WITHOUT NEUROGENIC CLAUDICATION	269,214
	721.3 - LUMBOSACRAL SPONDYLOSIS WITHOUT MYELOPATHY	261,644
	721.00 - CERVICAL SPONDYLOSIS WITHOUT MYELOPATHY	200,762
	722.4 - DEGENERATION OF CERVICAL INTERVERTEBRAL DISC	199,170
	724.4 - THORACIC OR LUMBOSACRAL NEURITIS OR RADICULITIS UNSPECIFIED	191,134
	719.45 - Joint pain-pelvis	180,717
	722.00 - Cervical disc displacement	135,434
	724.5 - Backache NOS	121,934
	782.00 - DISTURBANCE OF SKIN SENSATION	119,557
	723.00 - Cervical spinal stenosis	101,696
	729.5 - Pain in limb	92,735
Acute abdominal pain	789.00 - ABDOMINAL PAIN UNSPECIFIED SITE	953,023
	592.00 - Calculus of kidney	296,366
	562.10 - DIVERTICULOSIS OF COLON (WITHOUT HEMORRHAGE)	290,055
	789.09 - ABDOMINAL PAIN OTHER SPECIFIED SITE	244,273
	574.20 - Cholelithiasis NOS	208,354
	441.4 - ABDOMINAL ANEURYSM WITHOUT RUPTURE	181,572
	599.70 - Hematuria NOS	119,378

Condition Group	Diagnoses (over 90,000 instances)	Count
	593.9 - UNSPECIFIED DISORDER OF KIDNEY AND URETER	118,821
	789.59 - OTHER ASCITES	116,006
	591.00 - Hydronephrosis	99,634
	789.07 - Abdominal pain generalized	93,311
	592.1 - Calculus of ureter	90,818
Malignancies	185.00 - MALIGNANT NEOPLASM OF PROSTATE	877,637
	162.9 - MALIGNANT NEOPLASM OF BRONCHUS AND LUNG UNSPECIFIED	510,519
	174.9 - MALIGNANT NEOPLASM OF BREAST (FEMALE) UNSPECIFIED SITE	305,529
	202.80 - OTHER MALIGNANT LYMPHOMAS UNSPECIFIED SITE	223,174
	153.9 - MALIGNANT NEOPLASM OF COLON UNSPECIFIED SITE	152,546
	785.6 - Enlargement lymph nodes	148,027
	162.3 - MALIGNANT NEOPLASM OF UPPER LOBE BRONCHUS OR LUNG	142,008
	198.5 - SECONDARY MALIGNANT NEOPLASM OF BONE AND BONE MARROW	140,983
	189.0 - MALIGNANT NEOPLASM OF KIDNEY EXCEPT PELVIS	106,106
	733.13 - PATHOLOGICAL FRACTURE OF VERTEBRAE	98,626
	188.9 - MALIGNANT NEOPLASM OF BLADDER PART UNSPECIFIED	91,464
Headache and/or head injury	784.0 - Headache	962,247
	959.01 - Head injury NOS	785,735
	780.4 - Dizziness and giddiness	532,386
	780.39 - OTHER CONVULSIONS	142,353
	432.1 - Subdural hemorrhage	110,141
	473.9 - Chronic sinusitis NOS	94,400
	793.0 - NONSPECIFIC (ABNORMAL) FINDINGS ON RADIOLOGICAL AND OTHER EXAMINATION OF SKULL AND HEAD	91,338
Stroke symptoms	434.91 - CEREBRAL ARTERY OCCLUSION UNSPECIFIED WITH CEREBRAL INFARCTION	585,554
	780.2 - Syncope and collapse	350,693
	437.1 - OTHER GENERALIZED ISCHEMIC CEREBROVASCULAR DISEASE	308,800
	780.09 - ALTERATION OF CONSCIOUSNESS OTHER	225,278
	435.9 - UNSPECIFIED TRANSIENT CEREBRAL ISCHEMIA	219,095
	348.89 - OTHER CONDITIONS OF BRAIN	214,428
	433.10 - OCCLUSION AND STENOSIS OF CAROTID ARTERY WITHOUT CEREBRAL INFARCTION	184,395

Condition Group	Diagnoses (over 90,000 instances)	Count
	331.9 - CEREBRAL DEGENERATION UNSPECIFIED	180,873
	780.93 - Memory loss	114,723
	431.00 - Intracerebral hemorrhage	92,319
Pulmonary abnormal	793.19 - OTHER NONSPECIFIC ABNORMAL FINDING OF LUNG FIELD	455,388
	793.11 - Solitary pulmonary nodule	347,034
	51889 - Other lung disease not elsewhere classified (NEC)	262,038
	78609 - Respiratory abnorm NEC	258,766
	5180 - Pulmonary collapse	149,180
	4928 - Emphysema NEC	130,040
	486 - Pneumonia, organism NOS	108,858
	41519 - Pulm embol/infarct NEC	99,033
Face & neck injury	959.09 - Face & neck injury	359,886
	723.1 - Cervicalgia	338,880
	784.2 - Swelling in head & neck	196,720
	920.00 - Contusion face/scalp/neck	156,191
Altered mental status	780.97 - Altered mental status	674,437
Joint pain	71946 -PAIN IN JOINT INVOLVING LOWER LEG	141,112
	719.41 - PAIN IN JOINT INVOLVING SHOULDER REGION	137,459
	836.0 - TEAR OF MEDIAL CARTILAGE OR MENISCUS OF KNEE CURRENT	90,920
Pleural effusion NOS	511.9 - Pleural effusion NOS	348,286
Suspected condition	V71.4 - OBSERVATION FOLLOWING OTHER ACCIDENT	161,645
	959.9 - Injury-site NOS	116,478
Kidney condition	593.2 - Cyst of kidney, acquired	164,703
	996.73 - OTHER COMPLICATIONS DUE TO RENAL DIALYSIS DEVICE IMPLANT AND GRAFT	104,100
Malaise and fatigue	780.79 - Other Malaise and fatigue	208,861
Chest swelling	786.6 - SWELLING MASS OR LUMP IN CHEST	171,514
Head injury & stroke	298.9 - Psychosis NOS	170,665
Liver condition	573.8 - OTHER SPECIFIED DISORDERS OF LIVER	165,933
Injury NOS	959.19 - OTHER AND UNSPECIFIED INJURY OF OTHER SITES OF TRUNK	100,292

Table 5 shows the expanded groupings total counts.

Table 5. Expanded Condition Grouping Totals

Grouped Diagnoses (by similarity of symptoms)	Count
Heart condition	5,905,162
Low back & neck pain	2,982,442
Acute abdominal pain	2,811,611
Malignancies	2,796,619
Headache and/or head injury	2,718,600
Stroke symptoms	2,476,158
Pulmonary abnormal	1,810,337
Face & neck injury	1,051,677
Altered mental status	674,437
Joint pain	369,491
Pleural effusion NOS	348,286
Suspected condition	278,123
Kidney condition	268,803
Malaise and fatigue	208,861
Chest swelling	171,514
Head injury & stroke	170,665
Liver condition	165,933
Injury NOS	100,292

The results of the second assessment of condition groups in percentages is shown in Chart 3. This shows the 33% non-grouped diagnoses occurring at a count below 90,000, considered too low for our analysis to establish priority clinical areas for advanced imaging guidance.

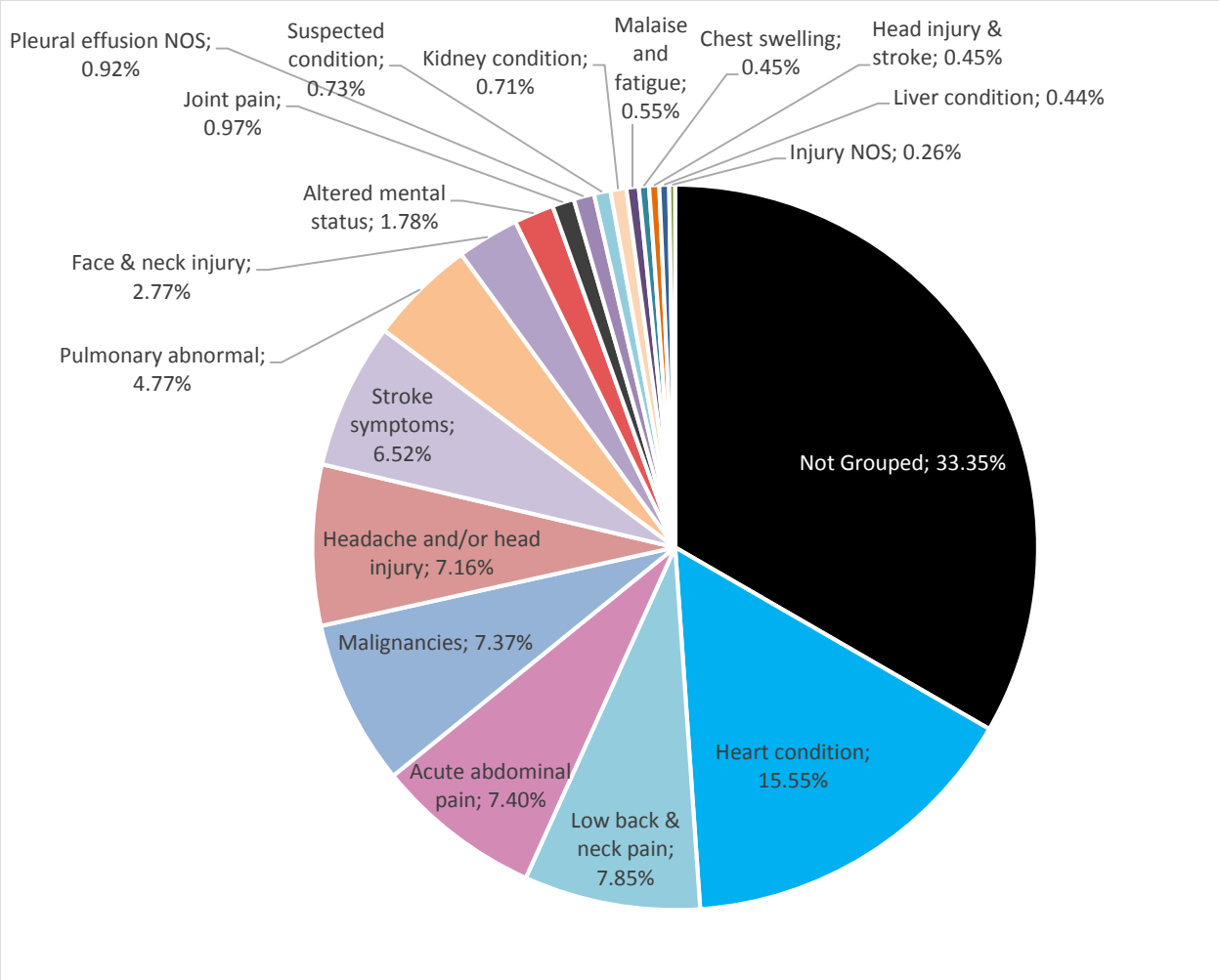


Chart 3. Expanded Condition Group Diagnoses Percentage in Relation to Total Number of Diagnoses

Based on these established condition groupings, the list of the top procedures associated with each condition group is shown in Table 6. The table is sorted by condition group and provides the top five advanced imaging procedures (by volume) associated with each group according to the Medicare claims data submitted to CMS in 2014.

Table 6. Top Procedures by Expanded Condition Group

Note: The top five procedures are listed per diagnosis condition group; red items are ones removed from the procedure counts.

HCPCS Code and Procedure Detail	Count	Procedure Grouping (Where Applicable)
Heart condition		
78452 - Myocardial perfusion imaging, tomographic (SPECT)	1,739,130	Myocardial perfusion imaging, tomographic (SPECT)
93018 - Cardiology stress testing interpretation & report only	1,065,525	Cardiology stress test
93015 - Cardiology stress testing	933,738	Cardiology stress test
93016 - Cardiology stress testing with physician without interpretation & reporting	929,488	Cardiology stress test
71275 - CT angiography, chest (non-coronary), with contrast material(s), including	370,602	CT angiography, chest (non-coronary), with contrast material(s),
Acute abdominal pain		
74176 - CT scan, abdomen and pelvis; without contrast material	1,132,034	CT scan, abdomen and pelvis
74177 - CT scan, abdomen and pelvis; with contrast material(s)	846,497	CT scan, abdomen and pelvis
74178 - CT scan, abdomen and pelvis; without contrast material in one or both body	216,269	CT scan, abdomen and pelvis
Q9967 - Low osmolar contrast material, 300-399 mg/ml iodine concentration, per ml	133,462	Removed
74174 - CT angiography, abdomen and pelvis, with contrast material(s), including	73,686	CT Angiography, abdomen and pelvis, with contrast material(s)
78227 - Hepatobiliary system imaging, including gallbladder when present,	35,275	Hepatobiliary system imaging
Headache and/or Head injury		
70450 - CT scan, head or brain; without contrast material	1,922,947	CT scan, head or brain; without contrast material
70551 - MRI brain; non contrast	187,497	MRI brain
70553 - MRI brain; with and without (w&wo) contrast	165,481	MRI brain

HCPCS Code and Procedure Detail	Count	Procedure Grouping (Where Applicable)
70486 - CT scan, maxillofacial area; without contrast material	130,010	CT scan, maxillofacial area; without contrast material
70544 - MRA angiogram brain - MRA, MRV; non contrast	53,569	MRA angiogram brain - MRA, MRV; non contrast
Low back and neck pain		
72148 - MRI lumbar spine; non contrast	1,044,061	MRI lumbar
72141 - MRI CSF flow; non contrast	359,027	MRI CSF flow; non contrast
72131 - CT scan, lumbar spine; without contrast material	256,668	CT scan, lumbar spine; without contrast material
72158 - MRI lumbar spine; w&wo contrast	197,633	MRI lumbar
72125 - CT scan, cervical spine; without contrast material	180,589	CT scan, cervical spine; without contrast material
Malignancies		
77014 - CT guidance for placement of radiation fields	797,712	CT guidance for placement of radiation fields
71260 - CT scan, thorax; with contrast material(s)	330,514	CT scan, thorax; with contrast material(s)
74177 - CT scan, abdomen and pelvis; with contrast material(s)	258,556	CT scan, abdomen and pelvis; with contrast material(s)
78815 - PET with concurrently acquired CT; skull base to mid-thigh	242,145	PET with concurrently acquired CT; skull base to mid-thigh
78306 - Bone scan whole body	159,147	Bone scan whole body
Stroke symptoms		
70450 - CT scan, head or brain; without contrast material	1,210,490	CT scan, head or brain; without contrast material
70551 - MRI brain; non-contrast	399,155	MRI brain

HCPCS Code and Procedure Detail	Count	Procedure Grouping (Where Applicable)
70553 - MRI brain; w&wo contrast	234,670	MRI brain
70544 - MRA angiogram brain - MRA, MRV; non-contrast	131,635	MRA angiogram brain - MRA, MRV; non-contrast
70498 - CT angiography, neck, with contrast material(s), including non-contrast	96,835	(CT) angiography, neck, with contrast material(s), including non-contrast
Pulmonary abnormal		
71250 - CT scan, thorax; without contrast material	695,282	CT scan, thorax
71260 - CT scan, thorax; with contrast material(s)	437,957	CT scan, thorax
71275 - CT angiography, chest (non-coronary), with contrast material(s), including	198,471	CT angiography, chest (non-coronary), with contrast material(s), including
Q9967 - Low osmolar contrast material, 300-399 mg/ml iodine concentration, per ml	62,885	Removed
78815 - PET with concurrently acquired CT; skull base to mid-thigh	50,651	PET with concurrently acquired CT; skull base to mid-thigh
78452 - Myocardial perfusion imaging, tomographic (SPECT)	50,607	Myocardial perfusion imaging, tomographic (SPECT)
Face and neck injury		
72125 - CT scan, cervical spine; without contrast material	486,541	CT scan, cervical spine; without contrast material
70450 - CT scan, head or brain; without contrast material	190,170	CT scan, head or brain; without contrast material
70486 - CT scan, maxillofacial area; without contrast material	86,213	CT scan, maxillofacial area; without contrast material
72141 - MRI CSF flow; non-contrast	82,751	MRI CSF flow; non-contrast

HCPCS Code and Procedure Detail	Count	Procedure Grouping (Where Applicable)
70491 - CT scan, soft tissue neck; with contrast material(s)	54,706	CT scan, soft tissue neck; with contrast material(s)
Altered mental status		
70450 - CT scan, head or brain; without contrast material	577,841	CT scan, brain
70551 - MRI brain; non-contrast	41,587	MRI brain
70553 - MRI brain; w&wo contrast	20,024	MRI brain
70470 - CT scan, head or brain; without contrast material, followed by contrast	5,957	CT scan, brain
72125 - CT scan, cervical spine; without contrast material	5,028	CT scan, cervical spine; without contrast material
Joint pain		
73721 - MRI joint-upper (hip, knee, ankle); non-contrast	188,660	MRI joint-upper (hip, knee, ankle); non-contrast
73221 - MRI joint-upper (shoulder, elbow, wrist); non-contrast	95,001	MRI joint-upper (shoulder, elbow, wrist); non-contrast
73200 - CT scan, upper extremity; without contrast material	11,332	CT scan, upper extremity; without contrast material
73700 - CT scan, lower extremity; without contrast material	11,006	CT scan, lower extremity; without contrast material
78315 - Bone and/or joint imaging; 3 phase study	10,885	Bone and/or joint imaging; 3 phase study
Pleural effusion NOS		
71250 - CT scan, thorax; without contrast material	170,829	CT scan, thorax
71260 - CT scan, thorax; with contrast material(s)	94,558	CT scan, thorax
71275 - CT angiography, chest (non-coronary), with contrast material(s), including	46,847	CT angiography, chest (non-coronary), with contrast material(s), including

HCPCS Code and Procedure Detail	Count	Procedure Grouping (Where Applicable)
74176 - CT scan, abdomen and pelvis; without contrast material	5,253	CT scan, abdomen and pelvis
74177 - CT scan, abdomen and pelvis; with contrast material(s)	5,021	CT scan, abdomen and pelvis
Suspected condition		
70450 - CT scan, head or brain; without contrast material	124,002	CT scan, head or brain; without contrast material
72125 - CT scan, cervical spine; without contrast material	79,850	CT scan, cervical spine; without contrast material
74177 - CT scan, abdomen and pelvis; with contrast material(s)	10,816	CT scan, abdomen and pelvis; with contrast material(s)
72131 - CT scan, lumbar spine; without contrast material	9,667	CT scan, lumbar spine; without contrast material
70486 - CT scan, maxillofacial area; without contrast material	8,885	CT scan, maxillofacial area; without contrast material
Kidney condition		
Q9967 - Low osmolar contrast material, 300-399 mg/ml iodine concentration, per ml	112,255	Removed
74177 - CT scan, abdomen and pelvis; with contrast material(s)	41,230	CT scan, abdomen and pelvis
74176 - CT scan, abdomen and pelvis; without contrast material	36,449	CT scan, abdomen and pelvis
74178 - CT scan, abdomen and pelvis; without contrast material in one or both body	27,766	CT scan, abdomen and pelvis
74183 - MRI abdomen; w&wo contrast	12,282	MRI abdomen; w&wo contrast
Q9966 - Low osmolar contrast material, 200-299 mg/ml iodine concentration, per ml	7,538	Removed
74170 - CT scan, abdomen; without contrast material, followed by contrast material(s)	6,990	CT scan, abdomen; without contrast material, followed by contrast material(s)

HCPCS Code and Procedure Detail	Count	Procedure Grouping (Where Applicable)
Malaise and fatigue		
70450 - CT scan, head or brain; without contrast material	144,310	CT scan, head or brain; without contrast material
70551 - MRI brain; non-contrast	15,803	MRI brain
70553 - MRI brain; w&wo contrast	7,451	MRI brain
70544 - MRA angiogram brain - MRA, MRV; non-contrast	3,066	MRA angiogram brain - MRA, MRV; non-contrast
70496 - CT angiography, head, with contrast material(s), including non-contrast	2,572	CT angiography, head, with contrast material(s), including non-contrast
Head injury & stroke		
70450 - CT scan, head or brain; without contrast material	137,222	CT scan, head or brain
70551 - MRI brain; non-contrast	15,269	MRI brain
70553 - MRI brain; w&wo contrast	8,401	MRI brain
70470 - CT scan, head or brain; without contrast material, followed by contrast	2,571	CT scan, head or brain
70544 - MRA angiogram brain - MRA, MRV; non-contrast	1,662	MRA angiogram brain - MRA, MRV; non-contrast
Chest swelling		
71260 - CT scan, thorax; with contrast material(s)	48,630	CT scan, thorax
71250 - CT scan, thorax; without contrast material	44,519	CT scan, thorax
77012 - CT guidance for needle placement, radiological supervision and interpretation	36,797	CT guidance for needle placement, radiological supervision and interpretation
Q9967 - Low osmolar contrast material, 300-399 mg/ml iodine concentration, per ml	7,142	Removed

HCPCS Code and Procedure Detail	Count	Procedure Grouping (Where Applicable)
78815 - PET with concurrently acquired CT; skull base to mid-thigh	6,214	PET with concurrently acquired CT; skull base to mid-thigh
71275 - CT angiography, chest (non-coronary), with contrast material(s), including	5,806	CT angiography, chest (non-coronary), with contrast material(s), including
Liver condition		
74177 - CT scan, abdomen and pelvis; with contrast material(s)	49,873	CT scan, abdomen and pelvis
74183 - MRI abdomen; w&wo contrast	23,886	MRI abdomen; w&wo contrast
74176 - CT scan, abdomen and pelvis; without contrast material	20,842	CT scan, abdomen and pelvis
74178 - CT scan, abdomen and pelvis; without contrast material in one or both body	12,701	CT scan, abdomen and pelvis
77012 - CT guidance for needle placement, radiological supervision and interpretation	11,708	CT guidance for needle placement, radiological supervision and interpretation
Injury NOS		
72131 - CT scan, lumbar spine; without contrast material	33,470	CT scan, lumbar spine; without contrast material
72128 - CT scan, thoracic spine; without contrast material	22,467	CT scan, thoracic spine; without contrast material
74177 - CT scan, abdomen and pelvis; with contrast material(s)	8,442	CT scan, abdomen and pelvis; with contrast material(s)
72192 - CT scan, pelvis; without contrast material	7,530	CT scan, pelvis; without contrast material
72125 - CT scan, cervical spine; without contrast material	6,577	CT scan, cervical spine; without contrast material

3.1 Details on Top Procedures by Condition Group

The following set of pie charts is drawn from the information presented in Table 6 and is designed to demonstrate the imaging procedures most closely associated with a given diagnosis or group of diagnoses determined to be of interest. For example, regarding the category of *Acute abdominal pain*, the chart demonstrates that CT scan of the abdomen, either with and/or without contrast, was overwhelmingly the most common procedure performed for investigation of this complaint. This result reflects the excellent utility of a CT scan of the abdomen to diagnose clinically important causes of abdominal pain in the Medicare age population, including diverticulitis, bowel obstruction, appendicitis, and abscess, all potential surgical emergencies. According to the April 1, 2015 edition of *American Family Physician*, CT scan is the initial imaging study of choice for evaluating patients presenting with acute or chronic right or left lower quadrant pain. Ultrasound was the study of choice for right upper abdominal pain; however, the CAMH team did not consider ultrasound in our analysis. The evidence rating was C, which stood for consensus, disease oriented, evidence, usual practice, expert opinion, or case series [2].

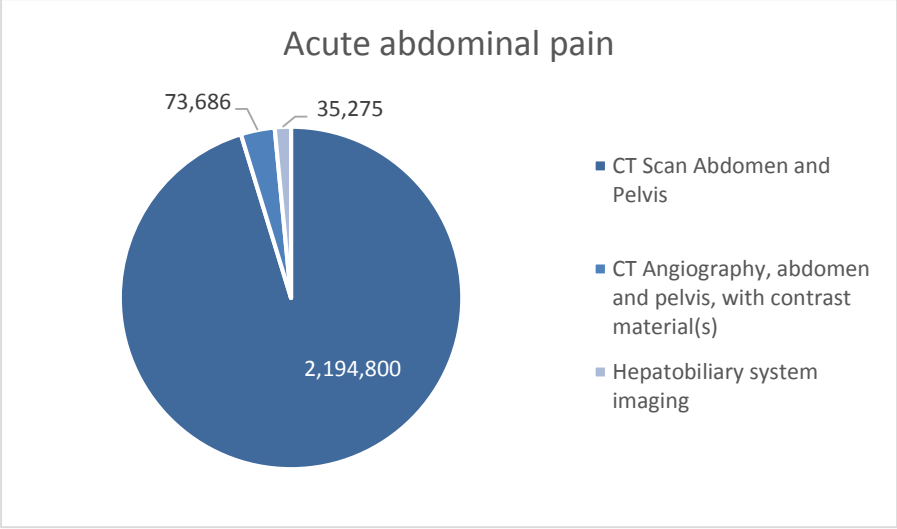


Chart 4. Acute Abdominal Pain Primary Procedures

By contrast, the grouped diagnosis *Stroke symptoms* shows a more varied distribution of CT scanning as well as various MRI and MRA procedures. This is commensurate with the practice of performing a CT scan without contrast to rule out the possibility of intracranial bleeding before any intervention can be considered. Because in an acute non-hemorrhagic stroke the CT scan shows normal results, an MRI with or without contrast would follow in many instances.

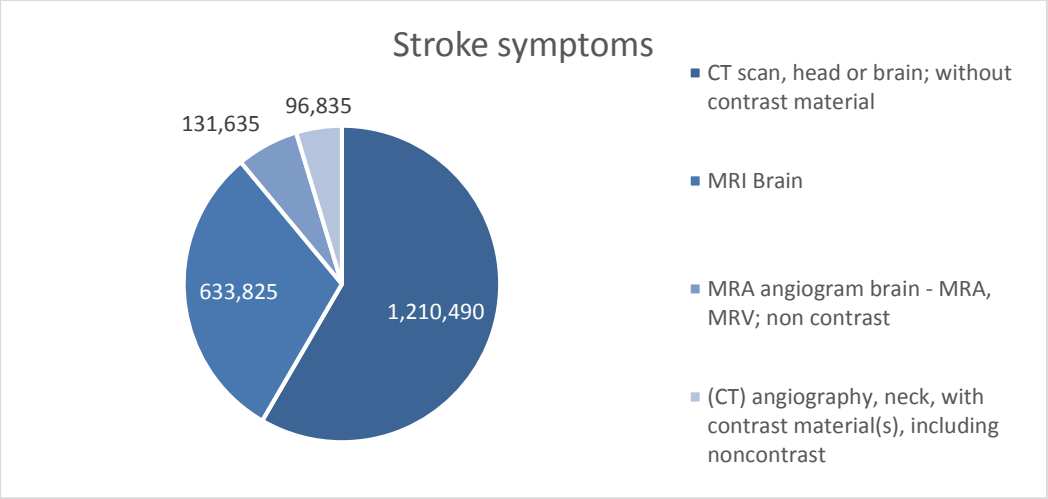


Chart 5. Stroke Symptoms Primary Procedures

In the largest diagnostic category, *Heart condition*, the CAMH team saw overwhelmingly that the procedure codes are related to diagnosis of coronary artery ischemia and/or infarct. Approximately 1.5 million nuclear medicine myocardial perfusion studies were performed, and another 2.9 million cardiology stress tests were undertaken for this purpose. Non-coronary artery CT angiography was done about 1/10th as often, likely to the vague electrical findings of pulmonary embolism which can be confused with coronary artery disease. The smallest procedure category, CT angiography, non-coronary, occurred about 350,000 times, likely due to the overlapping symptoms and electrocardiographic signs of angina and pulmonary embolism, as both disease entities can present with chest pain, shortness of breath, and electrical changes.

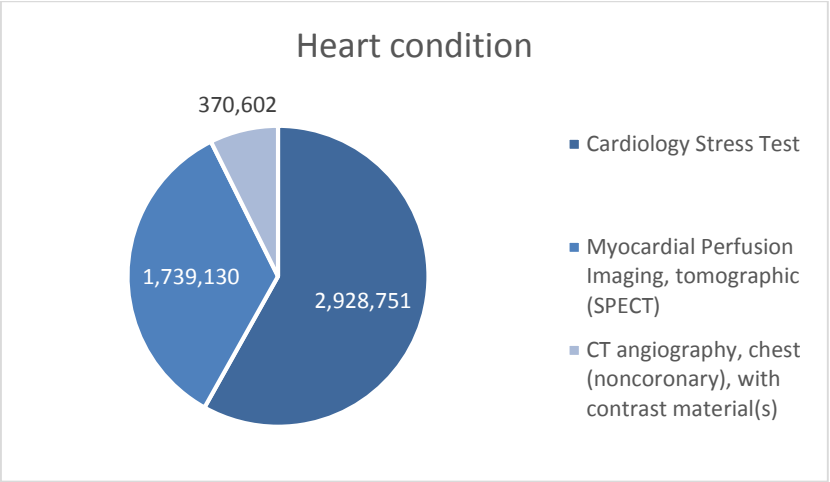


Chart 6. Heart Condition Primary Procedures

Headache and/or Head Injury showed a breakdown of diagnostic codes similar to that seen in the grouped category *Stroke symptoms*. However, the overwhelming majority of headache/head injury patients, ~85%, received a non-contrast CT scan of the head; with MRI and other CT scans of the neck and face making up the remaining 15%. This shows the high sensitivity and specificity of non-contrast head CT in demonstrating intracranial hemorrhage from injury or

rupture of an aneurysm or vascular malformation, a potentially life threatening condition with high morbidity and mortality. This is similar to the category of *Altered mental status*, where about 90% of patients received a CT scan of the head.

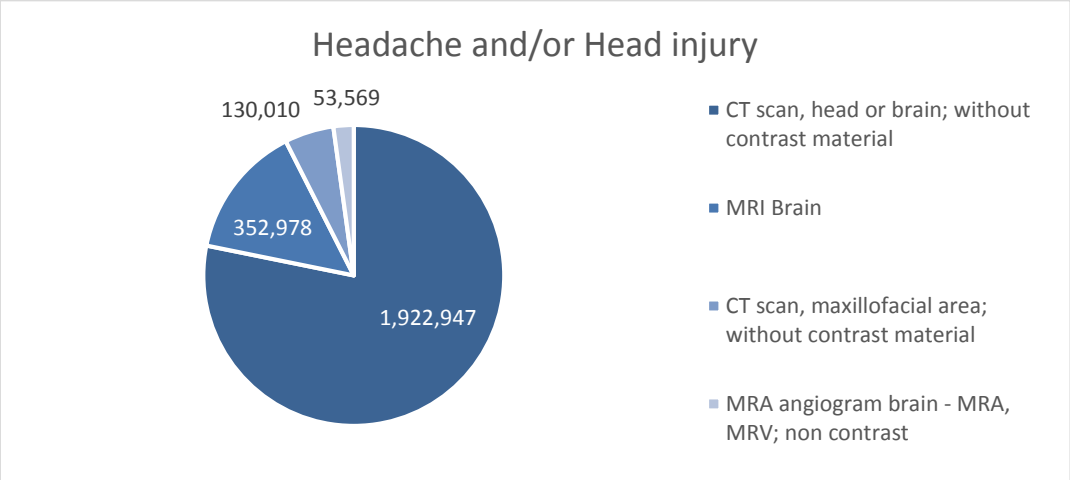


Chart 7. Headache and/or Head Injury Primary Procedures

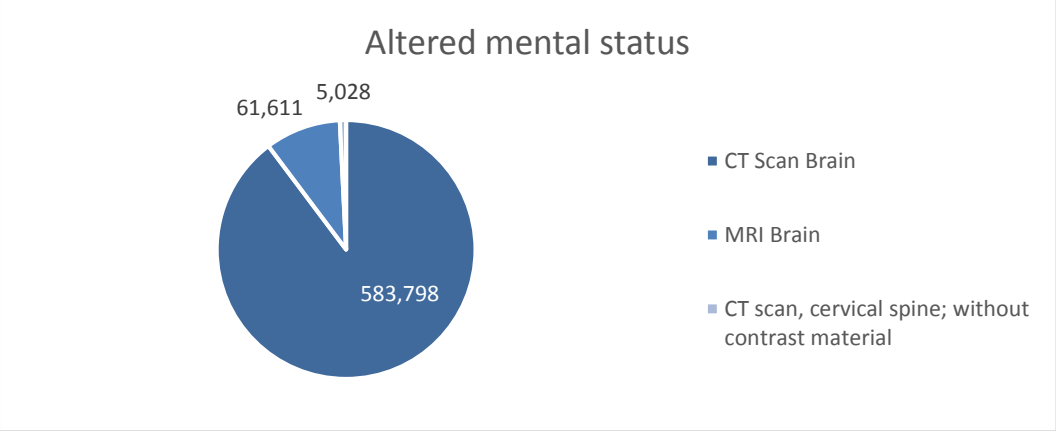


Chart 8. Altered Mental Status Primary Procedures

The combined category of *Malignancies* includes the procedures commonly used to initially stage cancer and for follow up to assess response to treatment. These include CT scans of the chest, abdomen, and pelvis, and bone scan.

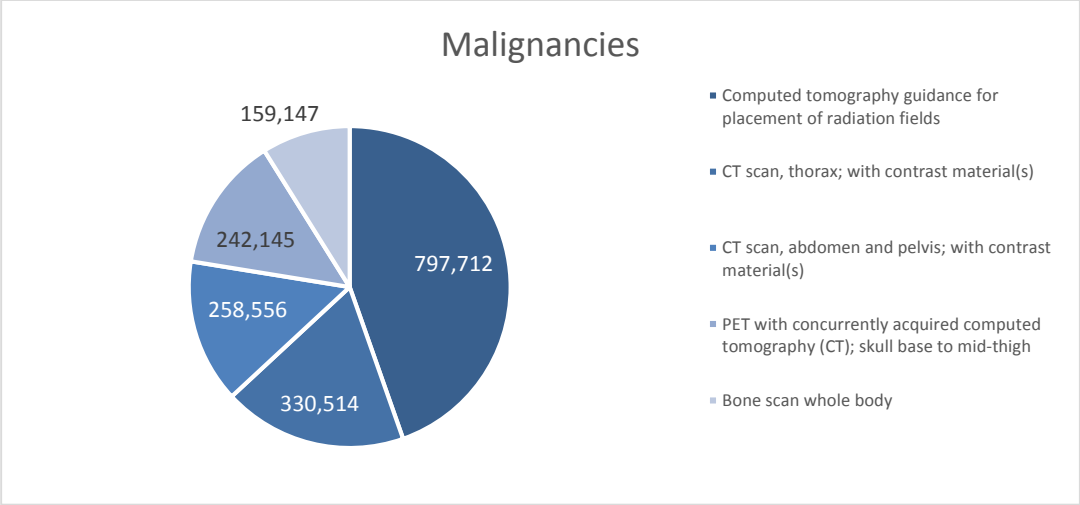


Chart 9. Malignancies Primary Procedures

For the combined category of *Low back and neck pain*, MRI is the procedure of choice, unless the patient has a contraindication, such as a pacemaker or aneurysm clips, and this is demonstrated in the breakdown of procedures, half of which were lumbar MRI exams, with the other half representing CT scans of the back and neck and MRI of the neck.

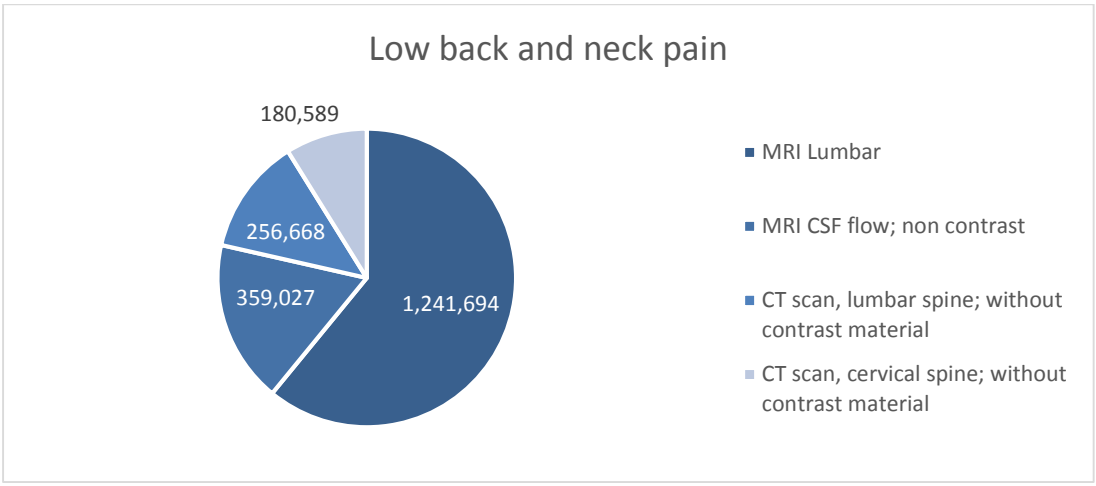


Chart 10. Low back and Neck Pain Primary Procedures

Similarly, the combined diagnostic group *Joint pain*, shows MRI utilized almost exclusively, except in those patients who must have a CT scan because of contraindications.

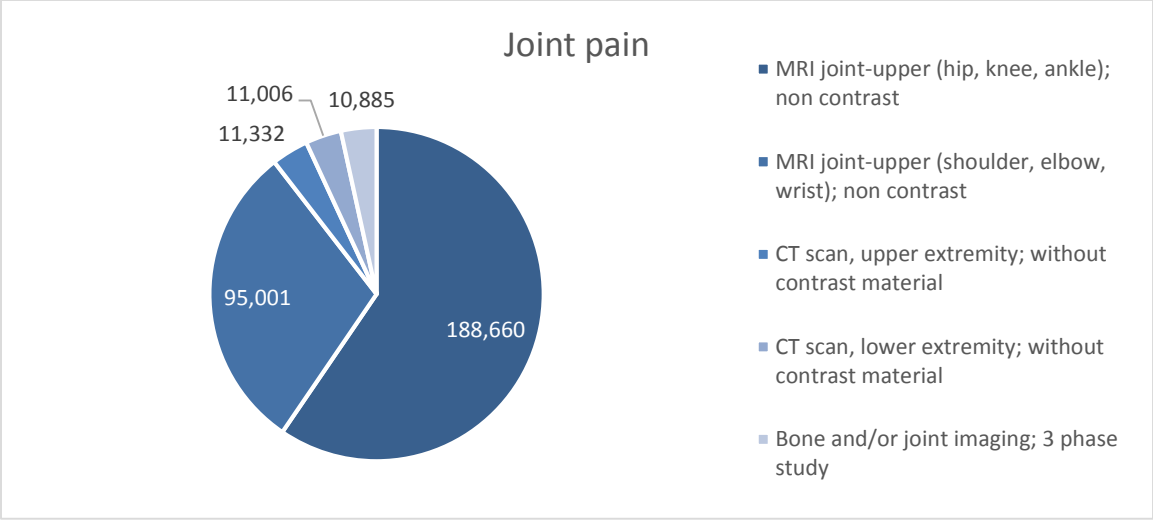


Chart 11. Joint Pain Primary Procedures

Face and neck injury is almost exclusively worked up with a CT scan of the head, face, and neck, owing to the ability of this modality to demonstrate bony structures in exquisite detail, diagnosing subtle fractures in patients who commonly have underlying osteoporosis and degenerative disease.

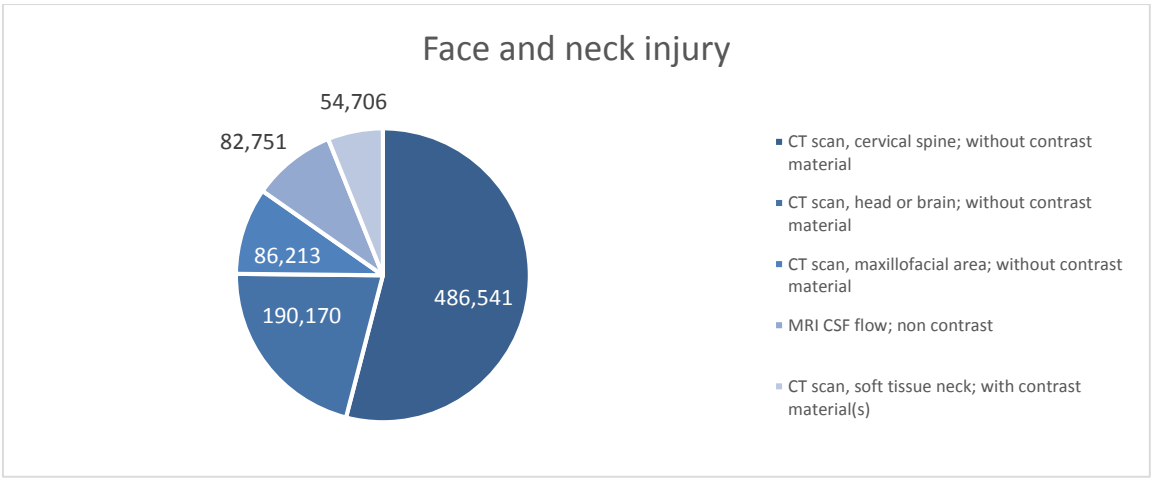


Chart 12. Face and Neck Injury Primary Procedures

The category *Pleural effusion NOS* is different from the above grouped diagnostic categories because it is a sign or finding and not a diagnosis onto itself. Furthermore, it is nonspecific and can be related to a host of conditions including heart failure, pneumonia, renal failure, hepatic disease, and other abdominal conditions such as infection or abscess. Because pleural effusion is commonly due to disease process in the chest and/or abdomen, a CT scan is the modality of choice for diagnostic investigation.

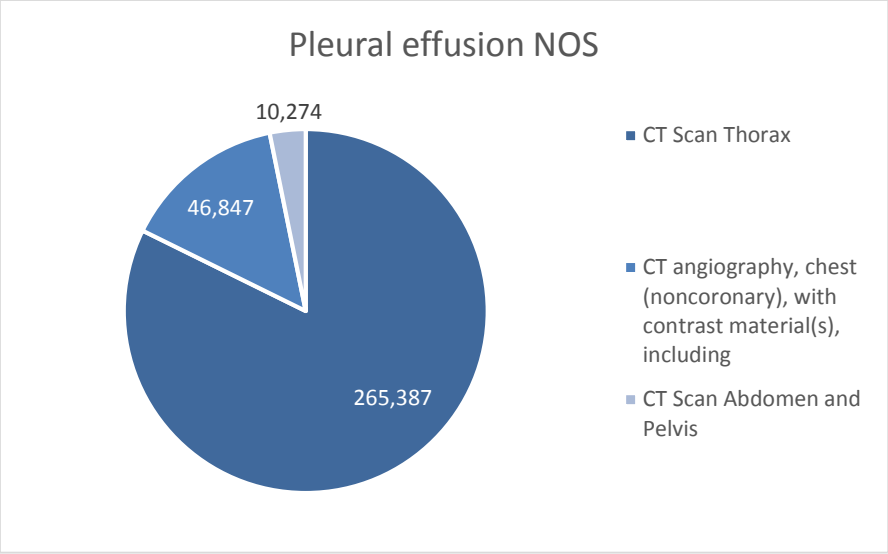


Chart 13. Pleural Effusion Primary Procedures

The category *Pulmonary abnormal* includes several non-specific respiratory conditions, such as emphysema, pneumonia, respiratory abnormal, and other lung disease. These are mostly chronic lung conditions and include bullous emphysema, chronic bronchitis, interstitial pneumonia, and pulmonary fibrosis. Chronic pulmonary and respiratory conditions, as well as the common diagnosis of a solitary pulmonary nodule, are worked up overwhelmingly by CT scan of the chest without or with contrast (1.1 million exams). Less commonly, pulmonary angiography was employed, and about 10 % of the time a PET/CT or nuclear medicine coronary perfusion exam was performed.

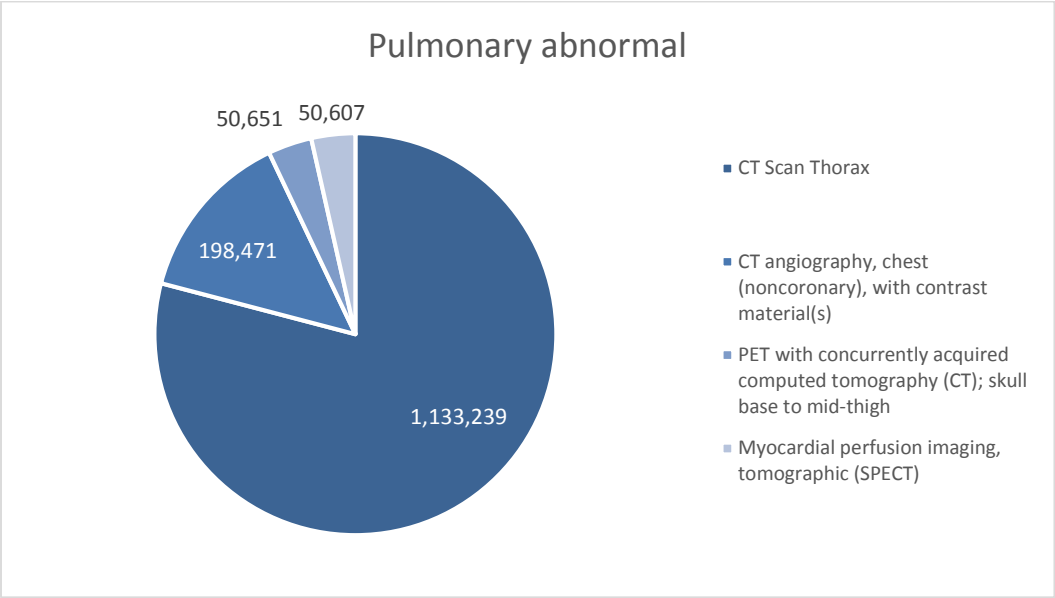


Chart 14. Pulmonary Abnormal Primary Procedures

Appendix B shows the breakdown pie charts for the rest of the diagnosis groups analyzed in the report and listed in Table 6. These procedures occured at a lower frequency and were considered less relevant for defining priority clinical areas for advanced imaging.

4. Discussion

Data derived from the CCW's 2014 Part B non-institutional claim line file was used to cross-walk from advanced diagnostics imaging procedure services rendered to the associated ICD-9 diagnosis codes. The CAMH team initially evaluated the top 20 diagnoses that emerged, based on their frequency, and clustered them based on underlying organ or condition to create diagnoses groups such as heart condition, stroke symptoms, malignancies, etc. By grouping similar diagnostic ICD-9 codes, we showed that the imaging modality/modalities associated with the group is appropriate, according to current accepted best practice standards (see Appendix A). For example, in the group *Stroke symptoms*, the team found about 2/3 of the patients received a non-contrast CT scan of the head, which is appropriate and necessary to rule out intracranial hemorrhage before treatment with blood thinners can be considered. About 1/3 of patients underwent an MRI or MRA to identify radiographically occult strokes, not demonstrated on CT scan but requiring treatment. Similarly, in the *Headache and/or Head injury* and *Altered mental status* groups, 75-90% underwent CT scans that were then deemed sufficient for diagnosis and treatment. In addition, the groupings allow us to develop a picture of which diagnoses had more impact on the population examined in relation to imaging procedures. This presents an opportunity to propose a list of clinical priority areas based on these findings.

In the diagnostic group *Heart condition*, the procedure most commonly performed was stress testing in some form, followed closely by myocardial perfusion imaging, which includes exercise or physiologic stress testing combined with nuclear radiotracer administration to directly visualize ischemic or infarcted heart muscle. This distribution makes sense, in that many of the abnormal electrical stress tests will need further imaging with myocardial perfusion scanning to determine if the patient needs treatment, and whether it would be stenting or coronary artery re-vascularization with bypass.

Headache is a common complaint in the general population and in the elderly, and makes up 25% of any neurologist's outpatient practice. While 90% of headaches are due to a primary headache disorder, there are several headache "red flags", which would prompt a CT scan in an urgent or emergent setting. These include: first or worst headache ever, onset after age 50, acute or sudden onset, sudden onset during exertion, neurologic symptoms or signs, or headache in a setting of malignancy. Several of these indications are particularly important in the Medicare age group. Head injury was grouped with headache as the two symptoms are commonly combined, and because both are treated the same way, with CT scans performed to rule out intracranial hemorrhage. Altered mental status is another common but non-specific complaint, and can co-exist with headache, stroke symptoms, or head injury. Altered mental status is also a common component of Alzheimer's dementia. Similarly, the grouped diagnosis *Face and neck injury* often resulted in CT scanning being performed on the affected area (face, neck or head) to rule out fracture or bleeding, and speaks to the strong propensity for accidental falls in this age group.

The grouped diagnosis *Pleural effusion NOS* deserves special analysis. Because this is a sign, and not a symptom, it is a difficult category to characterize, but because of its frequency it requires attention. The diagnosis of pleural effusion is nonspecific, and can be seen with primary lung conditions, such as pneumonia, tuberculosis or pulmonary infarct, as well as cancer, both primary and secondary. Congestive heart failure, renal failure, and hepatic cirrhosis or hepatitis can present with a pleural effusion, as can certain intra-abdominal processes, such as pancreatitis.

This large category can present with a variety of symptoms, including cough and shortness of breath, or can be an incidental finding due to the primary issue. The grouped diagnosis *Pulmonary abnormal* is similar in that it is not specific, and can encompass many differential possibilities including infection, malignancy, trauma, and chronic inflammatory conditions.

The grouped diagnosis *Malignancies* represents the number two cause of death of Americans over age 65, with lung cancer as the most frequent cause of death, followed by prostate, colon, and breast cancer in various orders depending on race and gender. CT scans of the chest, abdomen, and pelvis and bone scans or the commonly associated malignancy diagnosis, commensurate with the usual imaging for initial diagnosis and metastatic workup as well as for follow-up testing.

Neck and back pain are common complaints at all ages, but with advancing age there is a significant increase in osteoarthritis, spondylosis, and other degenerative changes, and a decrease in disc herniation. MRIs of the neck and back are the most common diagnostic procedures; however, in patients with contraindications, such as implanted pacemakers and aneurysm clips, CT scans will be substituted.

It is interesting to note that CT angiography, chest, non-coronary with contrast material appears as one of the top three procedures for the groupings of *Heart condition*, *Pulmonary abnormal*, and *Pleural effusion NOS*. This particular CT procedure is utilized primarily to exclude pulmonary embolism, a potentially life threatening and emergent diagnosis, which presents with shortness of breath, difficulty breathing, and diminished arterial oxygen saturation. Similarly, myocardial infarction, angina, pleural effusion with or without heart failure, and exacerbation of chronic obstructive pulmonary disease are all common diagnoses in the Medicare population and can present with this constellation of signs and symptoms.

There is an inherent disconnect between the Medicare ICD-9 diagnosis codes and the patient's chief complaint or presenting diagnosis. For example, chest pain is a common complaint which, when worked up, can result in any of the diagnosis codes in the grouping heart condition, pulmonary abnormal, or pleural effusion. Because the CAMH team does not have access to the symptoms that precipitated the office visit, we must extrapolate by using the information we do have, namely the diagnosis and procedure codes. To give a clinical example, if an elderly patient presents to a clinic complaining of shortness of breath, and a chest x-ray shows a right pleural effusion, a CT angiogram may be ordered to rule out the worst case scenario: pulmonary embolism. In a sedentary population, at risk for deep venous thrombosis, this is a reasonable concern. The CT angiography might show pulmonary embolism with lung infarction and pleural effusion, and that would account for that particular diagnosis code being used for billing purposes. Alternatively, the patient could have bacterial lobar pneumonia with pleural effusion, and be coded the same way.

The analysis presented holds true for all of the breakout pie charts presented for the main diagnoses, which were designed to display procedures according to diagnosis. The purpose of grouping similar diagnoses was to demonstrate that not only are they alike in symptomatology, but the modes of imaging investigation also correlate. For example, the grouped diagnosis *Acute abdominal pain* includes such diagnostic codes as acute diverticulitis, kidney stone, and bowel obstruction. All of these conditions will present with abdominal pain, and nearly all of the patients received a CT scan. In many cases, the CT results either determined the actual cause of nonspecific complaints, or confirmed the suspected cause, such as acute appendicitis.

The overall distribution of diagnosis codes, shown in Chart 4, is as expected for our patient demographics and helps in establishing the clinical priority areas based on our findings, and the known statistics for the Medicare population. According to the Centers for Disease Control and Prevention [1], heart disease, the most common indication for advanced imaging found, is the number one cause of death in this age group. *Stroke symptoms*, number four in imaging frequency, reflects its place as the number three killer of adults over age 65. The second leading cause of death over age 65 is cancer, which is represented in our data most specifically in the aggregated malignancies category. The fourth and fifth most common causes of death in the elderly patient vary by race, and includes chronic obstructive pulmonary disease (COPD), pneumonia/influenza, and diabetes. The grouped diagnosis *Pulmonary abnormal* includes COPD, pneumonia, and influenza and is the seventh most commonly submitted constellation of diagnosis codes. Pulmonary abnormal is a large and important category in imaging. In adults over age 65 in the United States, chronic lower respiratory disease is the third most common cause of death, and includes bullous emphysema, chronic bronchitis, interstitial pneumonia, and pulmonary fibrosis. The discrepancy in imaging and death rates is probably accounted for by the fact that many patients will not require advanced imaging techniques for diagnosis and follow up, since a chest x-ray will generally suffice. Importantly, Alzheimer's disease and several important renal diseases, such as nephritis and diabetic renal insufficiency/failure, are among the top 10 leading causes of death in the elderly. The imaging burden associated with Alzheimer's disease is borne out by the number of CT scans of the head performed for diagnoses such as psychosis and altered mental status.

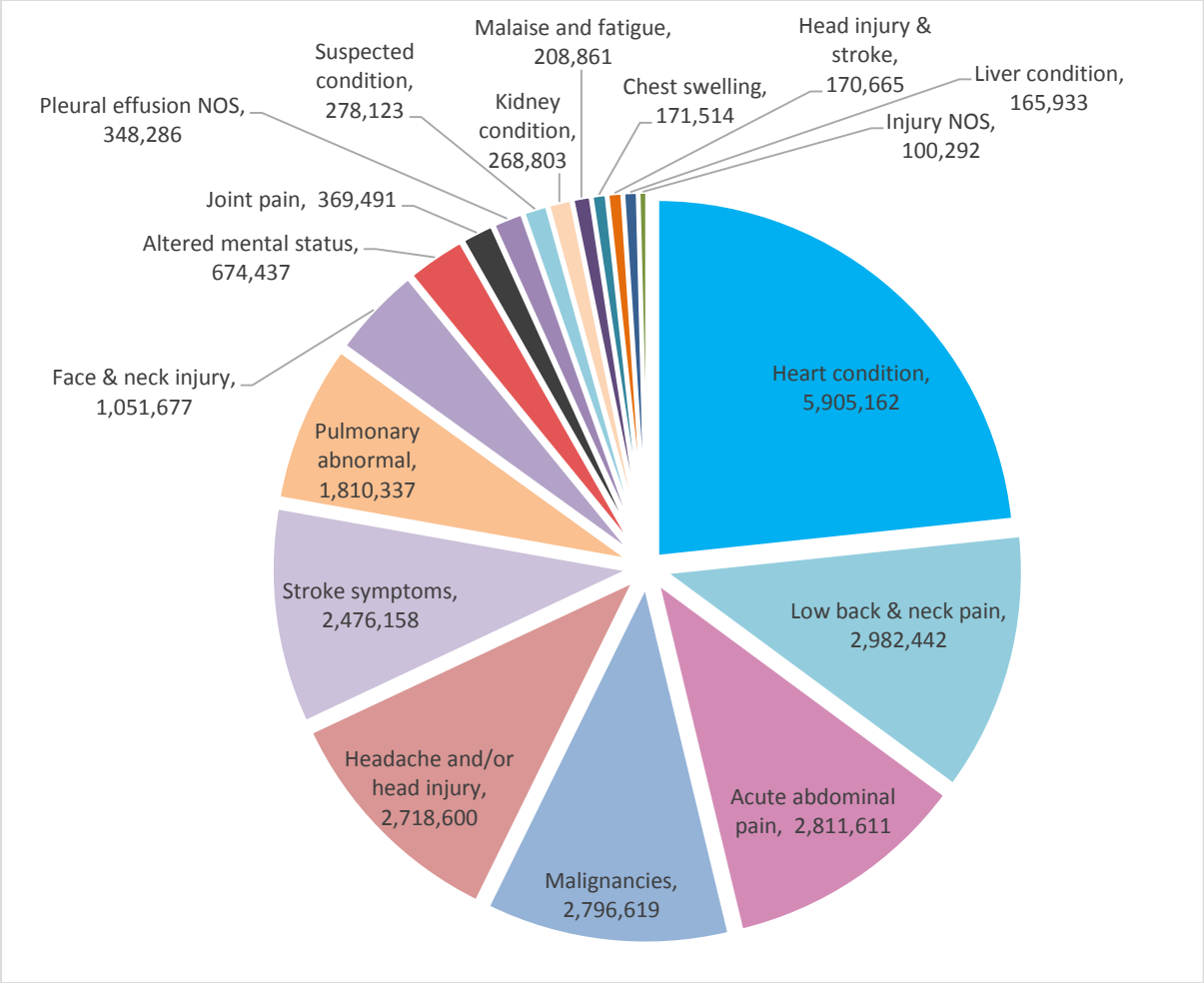


Chart 15. Cumulative Total of Expanded Diagnoses Clustered into Condition Groups

Of interest, death from unintentional injuries among adults aged 65 and older, about 2% of all deaths over age 65, was due to falls 55% of the time. This is most accurately reflected in the pie charts labeled "Headache and/or head injury" and "Face and neck injury". The propensity for falls increases with age, and is the only truly preventable cause of morbidity and mortality of the diagnosis codes analyzed. Older adults are also vulnerable to common infectious diseases including pneumonia, influenza, and septicemia, which are responsible for about 5.5 % of deaths in people aged 65 and older. The combined death rate from infectious disease has risen 25% in recent decades, and may be at least in part attributable to drug resistant strains of bacteria and nosocomial infections. Diagnoses related to infectious diseases can be seen in the *Pulmonary abnormal*, *Pleural effusion NOS*, and *Acute abdominal pain* categories. The large number of categories in the pie chart labeled "Low back and neck pain" speaks to these very common complaints in the aging population.

The grouped diagnoses that the CAMH team studied were developed from ICD-9 codes derived from outpatient facilities, such as doctor's offices and imaging centers. Thus, the potential for surgical emergencies was much lower than would be seen in a setting of an acute care hospital or emergency center.

Overall, the grouped diagnoses *Acute abdominal pain*, *Headache and/or Head injury* and *Face and neck injury* are the most likely categories to contain diagnoses that might lead to emergent or urgent surgery. For example, acute appendicitis in the elderly population frequently presents with vague symptoms, which might prompt an outpatient CT scan of the abdomen for investigation and result in surgery for the acute condition.

In contrast, most head and neck injuries severe enough to require emergency surgical intervention would present to an acute care facility; for example, a cervical spine fracture or severe facial bone trauma from a car accident or other high velocity impact. Occasionally, though, what might seem by history to be a trivial fall at home could result in severe facial trauma. Similarly, a minor neck injury in an older patient with underlying degenerative spondylosis, Diffuse Idiopathic Hypertrophic Spondylosis (DISH), or Ankylosing Spondylitis could result in an unexpected fracture.

Lastly, the grouping *Heart condition* could potentially have surgical emergencies if, for example, a treadmill or Myocardial Perfusion stress test showed severe, life threatening coronary artery ischemia, requiring immediate stenting or re-vascularization.

With respect to the groupings *Stroke symptoms*, *Altered mental status*, and *Headache and/or Head injury*, while many patients may have suffered an acute event, the likelihood of surgical intervention is low and would likely be limited to treatment for subdural, or rarely epidural, hematoma.

The remaining categories, including groups such as *Malignancies*, *Low back and neck pain*, and *Pulmonary abnormal*, refer to chronic conditions and are unlikely to contain diagnosis related to acute surgical emergencies.

In summary, the data analysis shows that advanced imaging techniques are being correctly and appropriately applied according to the grouped diagnosis codes the CAMH team developed and the corresponding imaging modalities used to investigate them. This analysis to correlate imaging procedure codes with diagnoses groups derived from claims data pointed to the following as clinical areas to prioritize based on the frequency of occurrence: heart condition, back and neck pain, acute abdominal pain, malignancies, headache and/or head injury, stroke symptoms, pulmonary abnormalities, face and neck injury, and altered mental status.

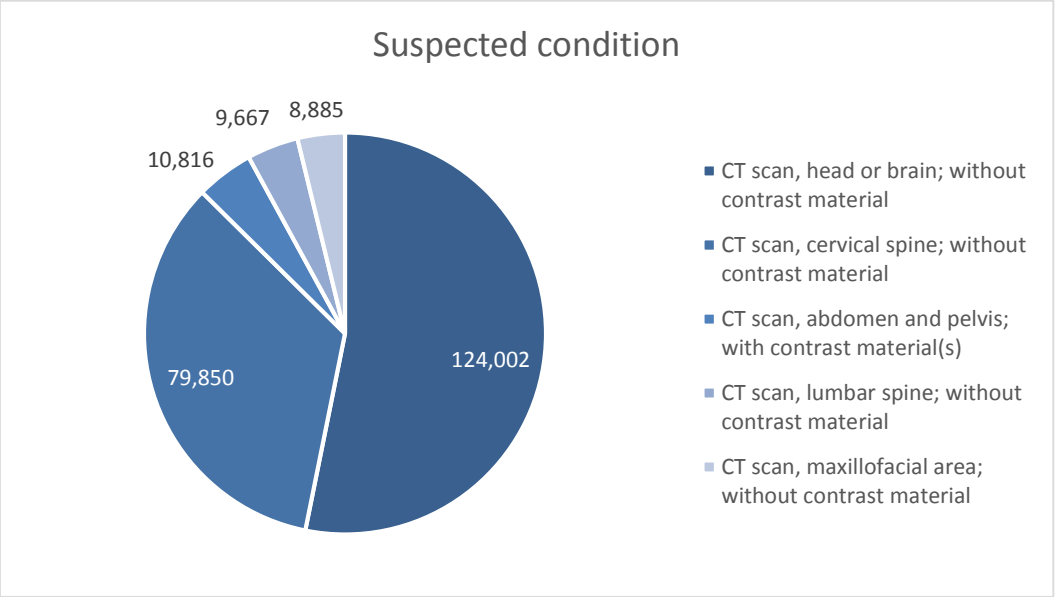
Appendix A. Best Practice Guidelines Examples

Best practice guidelines have been developed by many colleges and groups. Here is a sampling:

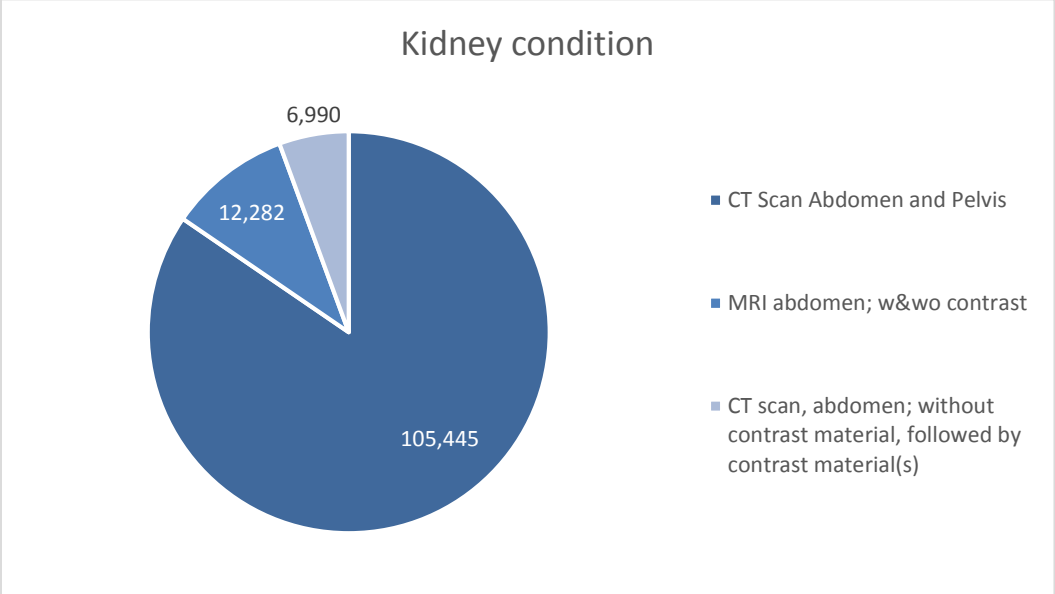
- American College of Radiology
- Radiologic Society of North America
- American College of Surgeons
- American Academy of Neurology
- American Association of Neurological Surgeons
- American College of Physicians
- Society of General Internal Medicine
- American College of Emergency Physicians
- Neurosurgical Society of America
- The American Geriatrics Society

Appendix B. Additional Breakdown Pie Charts

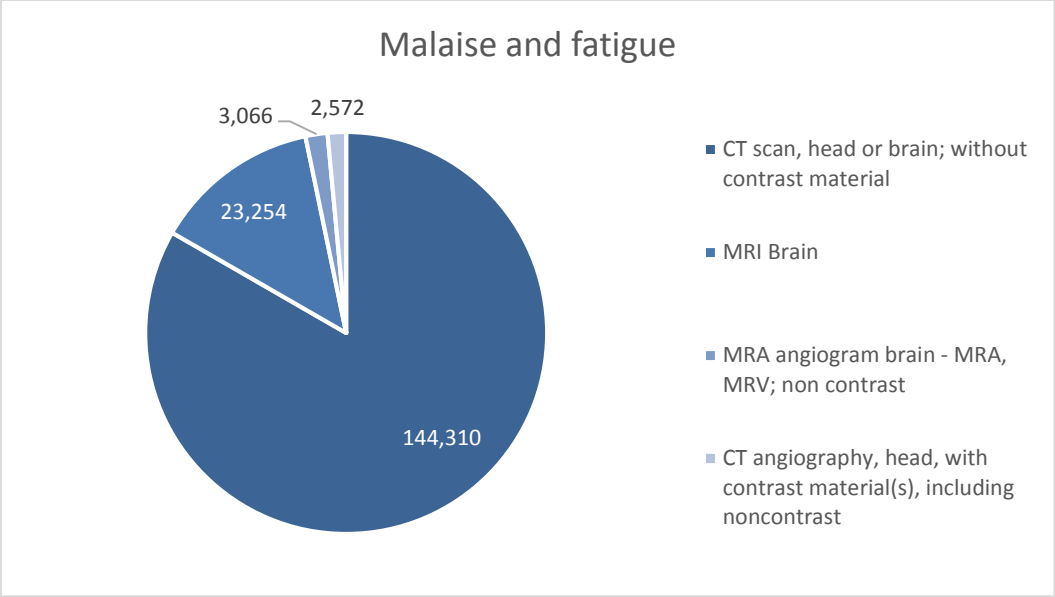
This appendix shows the breakdown pie charts of procedures for the rest of the diagnosis groups analyzed in the report and listed in Table 6. These procedures occurred at a lower frequency and were considered less relevant for defining priority clinical areas for advanced imaging.

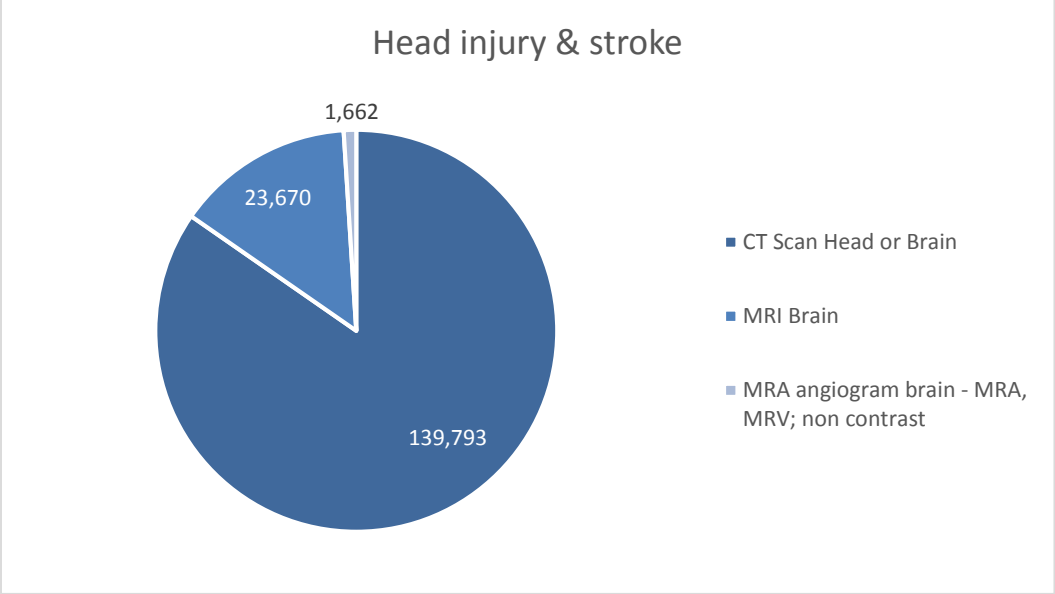


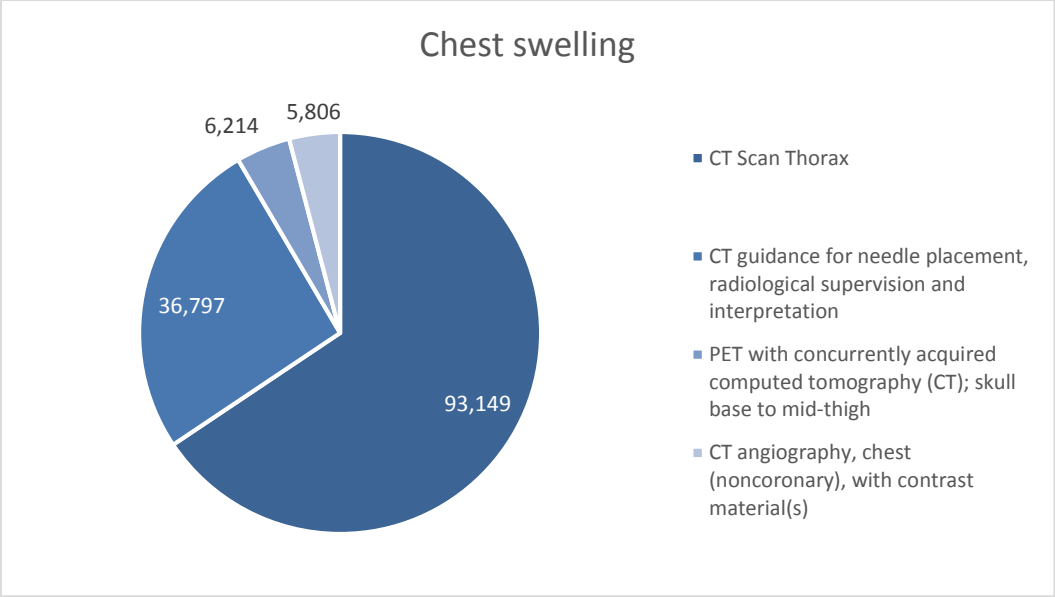
[3]

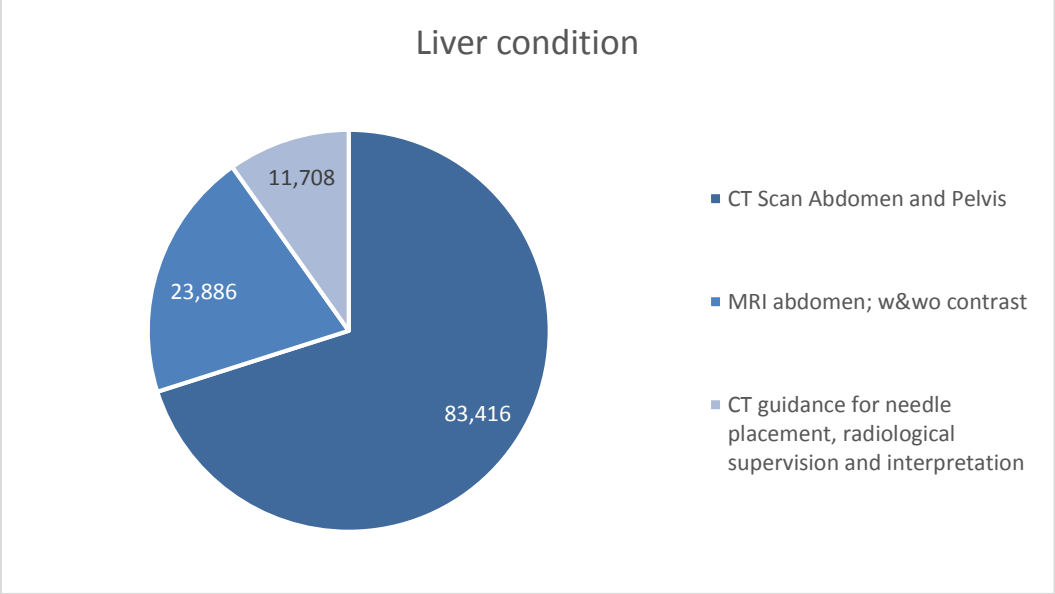


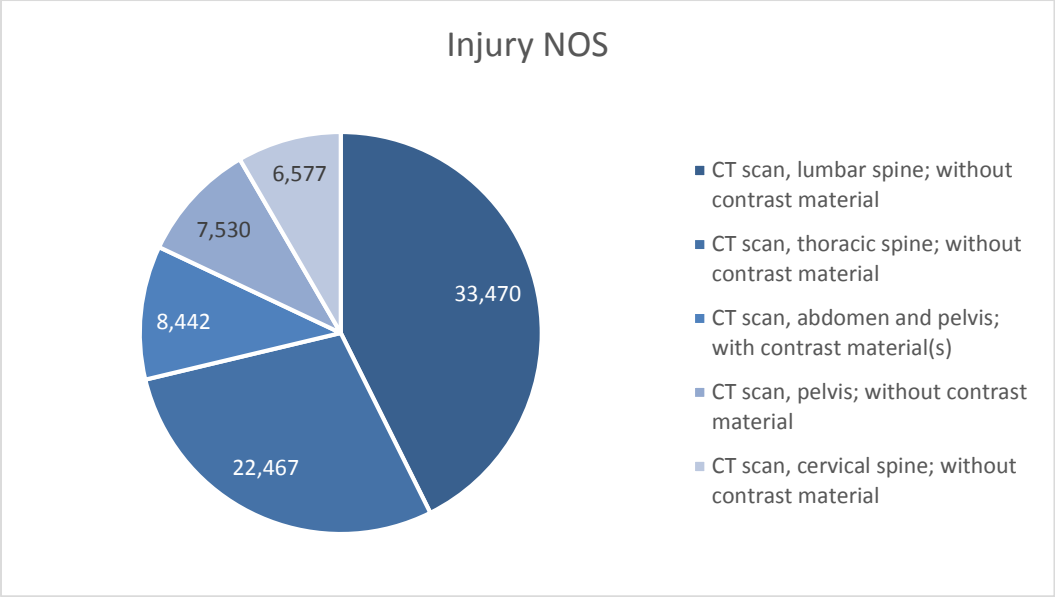
[3] Suspected condition is a condition group comprised of pre-diagnosis codes where a condition is suspected but has yet to be confirmed.


Malaise and fatigue
3,066
2,572
23,254
144,310
CT scan, head or brain; without contrast material
MRI Brain
MRA angiogram brain - MRA, MRV; non contrast
CT angiography, head, with contrast material(s), including noncontrast


Head injury & stroke
1,662
23,670
139,793
CT Scan Head or Brain
MRI Brain
MRA angiogram brain - MRA, MRV; non contrast


Chest swelling
6,214
5,806
36,797
93,149
CT Scan Thorax
CT guidance for needle placement, radiological supervision and interpretation
PET with concurrently acquired computed tomography (CT); skull base to mid-thigh
CT angiography, chest (noncoronary), with contrast material(s)


Liver condition
11,708
23,886
83,416
CT Scan Abdomen and Pelvis
MRI abdomen; w&wo contrast
CT guidance for needle placement, radiological supervision and interpretation


Injury NOS
33,470
22,467
8,442
7,530
6,577
CT scan, lumbar spine; without contrast material
CT scan, thoracic spine; without contrast material
CT scan, abdomen and pelvis; with contrast material(s)
CT scan, pelvis; without contrast material
CT scan, cervical spine; without contrast material

Acronyms

Term	Definition
CAMH	CMS Alliance to Modernize Healthcare
CCW	Chronic Condition Data Warehouse
CIO	Chief Information Officer
CMS	Centers for Medicare & Medicaid Services
COPD	Chronic Obstructive Pulmonary Disease
CSF	cerebrospinal fluid
CT	computed tomography
CTO	Chief Technology Officer
DISH	Diffuse Idiopathic Hypertrophic Spondylosis
ECG/EKG	Electrocardiogram
FAR	Federal Acquisition Regulation
FDA	U.S. Food and Drug Administration
FFRDC	Federally Funded Research and Development Center
FFS	fee-for-service
HCPCS	Healthcare Common Procedure Coding System
HHS	Department of Health and Human Services
HTA	Health Technology Assessment
ICD	International Classification of Diseases
mg	milligram
ml	milliliter
MRA	magnetic resonance angiogram
MRI	magnetic resonance imaging
MRV	magnetic resonance venography
NEC	Not Elsewhere Classified
NOS	Not Otherwise Specified
PET	positron emission tomography
SPECT	single-photon emission computed tomography
w&wo	with and without

List of References

[1] Centers for Disease Control and Prevention. (March 11, 2016). "National Center for Health Statistics: Older Persons' Health." Retrieved April 14, 2016, from http://www.cdc.gov/nchs/fastats/older-american-health.htm.

[2] Cartwright SL1, Knudson MP1. (April 1, 2015). "Diagnostic imaging of acute abdominal pain in adults. Am Fam Physician." 91(7):452-9. Retrieved May 20, 2016, from http://www.aafp.org/afp/2015/0401/p452.html.