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INFERENCING
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The Clinical Decision Support System designed to utilize the Training Set data in the MS Excel file must integrate three types of systems in order to provide the following four key functions:

- Give advice to physicians who order image studies
- Give advice to radiologist who read the imaging studies and produce reports providing their impression of whether the reason for the study is positive or negative
- Facilitate reimbursement of tests read
- Provide metrics to payers regarding the types of tests ordered and their related results

The three systems needed are a clinical terminology knowledge base that can interpret clinical codes and map these codes among disparate systems, an Electronic Healthcare System used to retrieve patient data, and an Inference Engine used to generate case-specific advice. An example of a clinical terminology knowledge base that could be used is SNOMED CT, which contains terminology related to clinical findings, symptoms, diagnoses, procedures, and body structures, among other clinical related data. Regarding the use of SNOMED CT within this context (i.e.: as it relates to the Training Set data), a physician would enter an order for an image study for a patient case based on information given via the patient Electronic Healthcare Record, or EHR (i.e.: symptoms such as head and neck pain). SNOMED CT would generate a related list of matching descriptions with their associated codes to determine the best procedure to use for diagnosis (i.e.: Computed tomography of cervical spine, SNOMED CT procedure code 241578008). This code would later be mapped to either an ICD 9 or ICD 10 code base extended from the patient Electronic Healthcare Record to an external information exchange portal for reimbursement payer purposes. For example, a patient's EHR may contain descriptive data on an X-Ray (i.e.: CT of cervical spine) performed to determine the cause of severe neck and head pain. The diagnosis could have been determined to be fluid collection causing the pain. Mapping the SNOMED CT code for both the CT scan and the 'fluid collection' diagnosis confirms a valid reason for payment of this test. In order for payment to be properly processed, the SNOMED CT code must be appropriately mapped to the ICD-9 or ICD 10 payer code reflective of the identical test and diagnosis that can be used by the insurance carrier to authorize payment. Mapping these codes with as much precision as possible is pertinent not only for payment reasons but also for purposes of metrics used to determine the types of results the tests are critical to providing as well as identifying the corresponding physicians or specialties that are requesting the specific tests. Understanding the metrics pertaining to this information is a foundation to helping physicians make more informed decisions. Healthcare organizations are also able to provide better quality care in addition to ensuring patient safety and improved outcomes. For example, the ***Positive Predictive Value***, or **PPV**, (i.e.: test is statistically valid and can truly identify a person as <u>*having*</u> a disease or ailment) and ***Negative Predictive Value***, or **NPV**, (i.e.: test is statistically valid and can truly identify a person as <u>*not having*</u> a disease or ailment) could be useful in determining the accuracy of specific radiologic tests. For instance, in a clinical trial the PPV for a digital mammography versus using a tomosynthesis with a digital mammography was 4.3% versus 6.4% for recalls (Stenger, 2014). This basically confirmed that the inclusion of a tomosynthesis with a digital mammography resulted in a decrease in recall rates and an increase in cancer detection rates based on a higher PPV, indicative of more accuracy.

Moving forward, since the Training Set data will also be needed by radiologists to produce reports (i.e.: reports will give the radiologists' impression of whether the reason for the study is positive or negative), rules should be applied that will allow the inference engine to retrieve relevant information. This information could be generated based on a decision tree model that uses backward chaining to help the radiologist to arrive at a conclusion that determines if the reason for the study (or physician's request for a certain radiology test) was positive or negative. To illustrate let's refer to the Training Set data in the Excel sheet. In Row one, Column one, the Impression section indicates: ***Involutional changes and microvascular white matter changes. No evidence of intracranial hemorrhage, mass lesion, or acute territorial infarct***. In this scenario the patient is on a medication referred to as Coumadin and has collapsed. The data can be viewed from the following evaluation perspective of knowledge engineering:

Column L (i.e.: **Indication Justified by Positive Impression Finding(s)?**) can automatically be populated to reveal if the indication was justified based on a set of rules determined by **Column F** (i.e.: Study Reason Interpreted: Patient Collapse and taking Coumadin). This could be accomplished via a decision tree that examines the clinical codes in **Column G** (i.e.: Loss of consciousness (finding): 419045004 & Warfarin (product): 48603004) and references it to the patient events in **Column F**. These codes would then be applied to any relevant searches of a clinical database that referenced clinical studies/trials where patients with these same factors (i.e.: fall/collapse with Coumadin) were given specific CT scans or test procedures that aided in a beneficial diagnosis based on identical chief complaints or events. In this case, the '**indications justified**…' column would automatically generate "No" based on the positive impressions findings, which state "***No evidence*** *of intracranial hemorrhage, mass lesion, or acute territorial infarct."* Basically, this would mean one of two things given the spreadsheet data; either the type of radiology test administered is not justified based on the scope of the impression findings, or the study itself warrants no need for further evaluation based on a positive or negative outcome (i.e.: positive and negative coded column data in Excel sheet). Although this example may slightly differ from the actual point of the Training Set data, it demonstrates the concept in affectively applying a set of logical sequences to arrive at a decision based on the aforementioned scenario. The actual data itself is able to render optimal system performance based on a precise set of clinical codes that can be mapped through various systems and descriptive concepts that will yield relevant searches based on algorithms that rely on decision tree analysis techniques. Any improvement in performance would be solely contingent upon the degree of granularity practiced with regards to terminology and concept descriptions used for searches and any scalability adjustments taken into consideration in terms of increased data and the number of algorithm techniques used for decision analysis. In other words, a balance needs to exist among these elements in order for performance to continue at optimal levels. In closing, it is worthy to note how the Training Set data can be utilized in a 2X2 table to illustrate the precision that exists (or does not exists) between various CT scans performed with contrast and without contrast and their specific findings (i.e.: are positive findings more likely to be accurate on CT scans performed without contrast or are negative findings less than likely to be accurate on CT scans performed with contrast (see attached appendix)).

Appendix:

Notes: ***Negative findings*** are defined as CT Scans that reveal no abnormalities that pose potential risk factors for disease or other medical issues.
Example: No evidence of intracranial hemorrhage, mass lesion, or acute territorial infarct.

Positive findings are defined as CT scans that reveal abnormalities that could pose potential risk factors for disease or other medical issues
Example: Evidence of Arachnoid cyst in the posterior fossa is identified and causing mild mass effect that could be causing severe headache.

	CT Scan w/contrast	**CT Scan W/O Contrast**	**TOTALS**
Positive Findings	**3 (TP)**	**3 (FP)**	**6**
Negative Findings	**17 (FN)**	**11 (TN)**	**28**
TOTAL	**20**	**14**	**34**

Explanation:

Sensitivity = TP / (TP+FN)
= 3/ (17+3)
=.15
*Therefore 15% of x-rays performed ***with contrast*** will reveal positive findings, not being able to exclude patients from factors that pose potential risk factors for disease or other medical issues

Specificity = TN / (FP + TN)
= 11 / (3 + 11)
= .79
*Therefore 79% of x-rays performed ***without contrast*** will reveal negative findings, excluding patients from factors that pose potential risk factors for disease or other medical issues.

Among the x-rays with positive findings, only 50% of the tests will be accurate, which means 3 tests performed with contrast will be right (i.e.: positive findings are accurate), and 3 test performed without contrast will be wrong (i.e.: yielding a false positive finding). This analysis was derived at using the **Positive Predictive Value**:

PPV = TP / (TP + FP)

PPV= 3 / (3 + 3) = .5

Among the x-rays with negative findings, only 61% of these test will be accurate, which means 11 tests performed without contrast will be right (i.e.: negative findings are accurate), and 17 tests performed with contrast will be wrong (i.e.: yielding a false negative finding). This analysis was derived at using the **Negative Predictive Value**:

NPV = TN / (FN + TN)
NPV=17/ (17 + 11) = .61

From a theoretical perspective, any x-ray performed with contrast risk a higher chance of producing erroneous results. This could be due to any number of reasons, like contrast dyes causing flaws as well as an untrained eye that is not experienced enough to detect the smallest yet most significant details shown by the contrast dyes.

References:

Stenger, Matthew. (2014, September). Adding Tomosynthesis to Digital Mammography Decreased Recall Rate, Increased Cancer Detection Rate in Breast Screening. The ASCO Post. Retrieved from: http://www.ascopost.com/issues/september-15,-2014/adding-tomosynthesis-to-digital-mammography-decreased-recall-rate,-increased-cancer-detection-rate-in-breast-cancer-screening.aspx

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