# Experiences with an enterprise-wide SNOMED CT based self-service analytics solution

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## *SNOMED CT Expo 2017*

*Friday 20 Oct 2017, 11am (stream B)*

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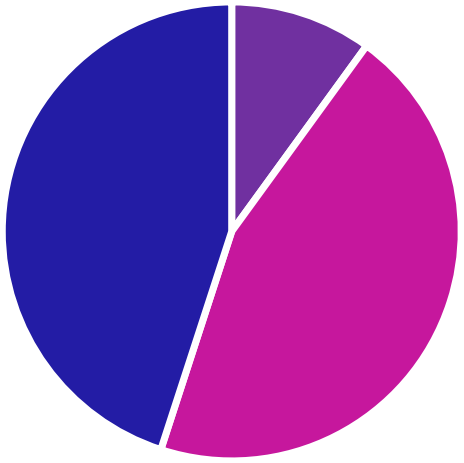
# HCAS Analytics Goals

## Seamless integration of structured and unstructured data

Comprehensive use of available clinical data

Traditional Healthcare BI data source



- Coded Healthcare Data
- Qualitative Human Data
- Quantitative Machine Data

## Self service analytics

Benefits a broad range of users and use-cases

Intuitive Data Access

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# HCAS Architecture

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EMR

Inpatient records

Claims

Pharmacy

Labs

Radiology

Applications

**Data ingestion/ data enrichment**

Mappers

Pattern matchers

Ontology tagger

ETL/ ELT

**Knowledge sources**

CLINVAR

ICD9/10

SNOMED

**Big Data engines**

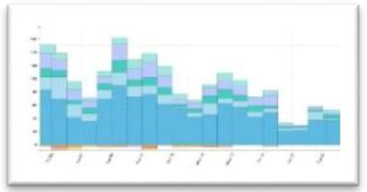
IDOL

Interprets human information for HCAS

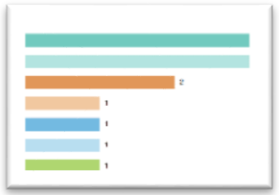
Vertica

HCAS Big Data analytics

**Healthcare analytics**



Population trending



Length of stay reporting

Population health

**Point of care apps**

Quality control officer

Population health executive

Analyst

Clinicians

Member / patient

Care coordinators

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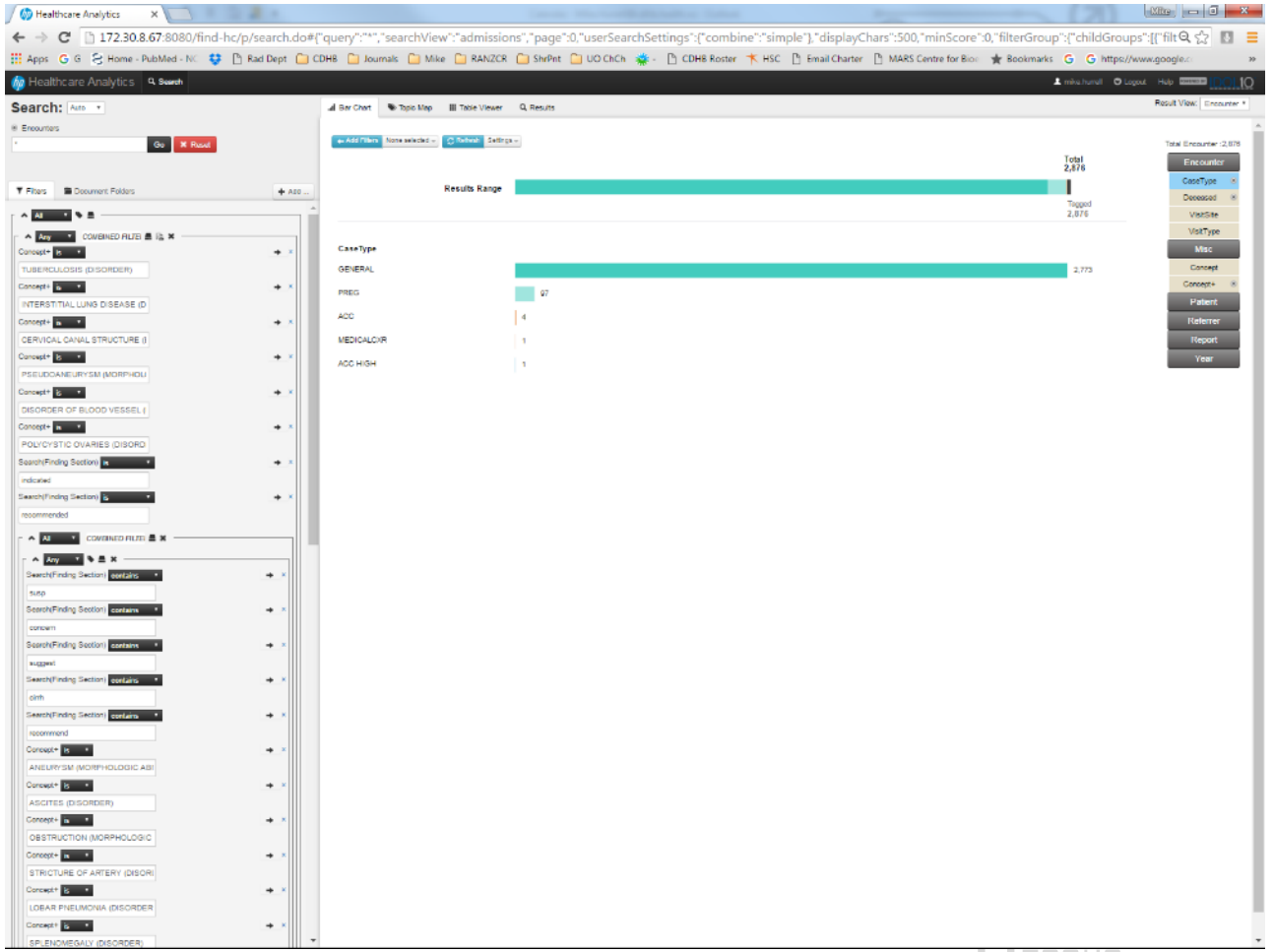
# Healthcare Analytics Solution
# Radiology Pilot

- Data
  - 5 years of selected radiology reports (13601 records)
- System features
  - SNOMED CT ontology
  - Seamless structured/free-text filter creation
  - Cohort generation of reports with actionable findings
  - Collaborative workflow
    - Cohort assignment
    - Computer assisted chart abstraction
  - Cohort export for interoperability with other IT systems

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# Healthcare Analytics Solution Radiology Pilot

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- 13000+ reports “printed” to non-existent printer due to incorrect setup
- Concern over non-acute ACR category 3 abnormalities
  - Non-acute
  - Require communication within days/weeks
  - Possible morbidity/mortality if ignored
  - eg aneurysm, malignancy
- Benefits
  - Reliability
  - Efficiency
  - Transparency
- Risks
  - Requires hypothesis driven use
  - Dynamic accuracy

| | ACR category 3 abnormalities |
|---|---|
| **Body System** | **Term** |
| **General** | Neoplastic disease (Disorder) |
| | Proliferation (Morphologic abnormality) |
| | Aneurysm (Morphologic abnormality) |
| | Stricture of artery (Disorder) |
| | Lymphadenopathy (Disorder) |
| | Tuberculosis (Disorder) |
| **Chest** | Cardiomegaly (Disorder) |
| | Lobar pneumonia (Disorder) |
| | Collapse (Morphologic abnormality) |
| | Interstitial Lung Disease (Disorder) |
| **Abdomen** | Ascites (Disorder) |
| | Splenomegaly (Disorder) |
| | Upper urinary tract dilatation and obstruction (Disorder) |
| | Dilatation of ureter (Disorder) |
| | Kidney stone (Disorder) |
| | Calculus (Morphologic abnormality) |
| | Malformation of urachus (Disorder) |
| | Intestinal obstruction (Disorder) |
| | Obstruction (Morphologic abnormality) |
| | Polycystic Ovaries (Disorder) |
| **Musculo-Skeletal** | Congenital skeletal dysplasia (Disorder) |

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# Enterprise Deployment Data Specs

| Scope | Record Unit | Total Records | distinct patients | Concept tags | Unique concepts |
|---|---|---|---|---|---|
| patient | (patients) | 2,351,213 | 1,840,214 | 869,350,771 | 86,638 |
| inpatient | (admissions) | 762,330 | 275,418 | 279,347,309 | 66,904 |
| outpatient | (appointments) | 7,121,904 | 477,257 | 104,906,370 | 30,616 |
| radiology | (radiology events) | 3,085,365 | 597,039 | 196,522,015 | 22,892 |
| referrals | (referrals) | 1,681,413 | 734,120 | 108,047,094 | 50,821 |
| labs | (lab studies) | 137,366,695 | 1,327,929 | | |


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# Radiology Scope Example

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## Primary Tables

**radiology_event**
- dim_ip_event_fact_key
- dim_op_event_fact_key
- body_part_description
- description
- exam_type
- nhi
- referrer
- site_description
- unique_id_case_event
- visit_end_date_time
- visit_start_date_time
- visit_status_description
- dss_update_time
- patient_merge_hash
- radiology_master_id
- age_at_visit

**radiology_master**
- radiology_master_id
- event_flag
- unique_id_case_event
- unique_id_case_referral_master
- patient_merge_hash
- start_date

**radiology_referral_notes**
- referral_reason
- referral_reason_text
- unique_id_case_referral
- unique_id_case_referral_master
- unique_id_referral_notes
- dss_update_time
- patient_merge_hash
- radiology_master_id

**radiology_procedure**
- exam
- exam_type
- quantity
- unique_id_case_event
- unique_id_case_procedure
- dss_update_time
- patient_merge_hash
- radiology_master_id

**radiology_report**
- dictation_dtm
- report_author
- report_distributed_dtm
- report_status_description
- report_text
- unique_id_case_event
- unique_id_case_procedure
- dss_update_time
- patient_merge_hash
- radiology_master_id

**radiology_referral**
- dim_ip_event_fact_key
- dim_op_event_fact_key
- body_part
- case_referral_description
- exam_type
- issued_date
- nhi
- referral_status_description
- referrer
- site_description
- unique_id_case_event
- unique_id_case_referral
- unique_id_case_referral_master
- dss_update_time
- patient_merge_hash
- radiology_master_id
- age_at_referral

## Joining Table

**patient**
- dim_patient_key
- dss_patient_merge_key
- domicile_display
- ethnicity_level_4
- display_name
- dob
- dod
- gender
- master_nhi
- master_nhi_encrypted
- dss_start_date
- dss_end_date
- dss_update_time
- patient_merge_hash
- last_valid_record
- deceased_flag



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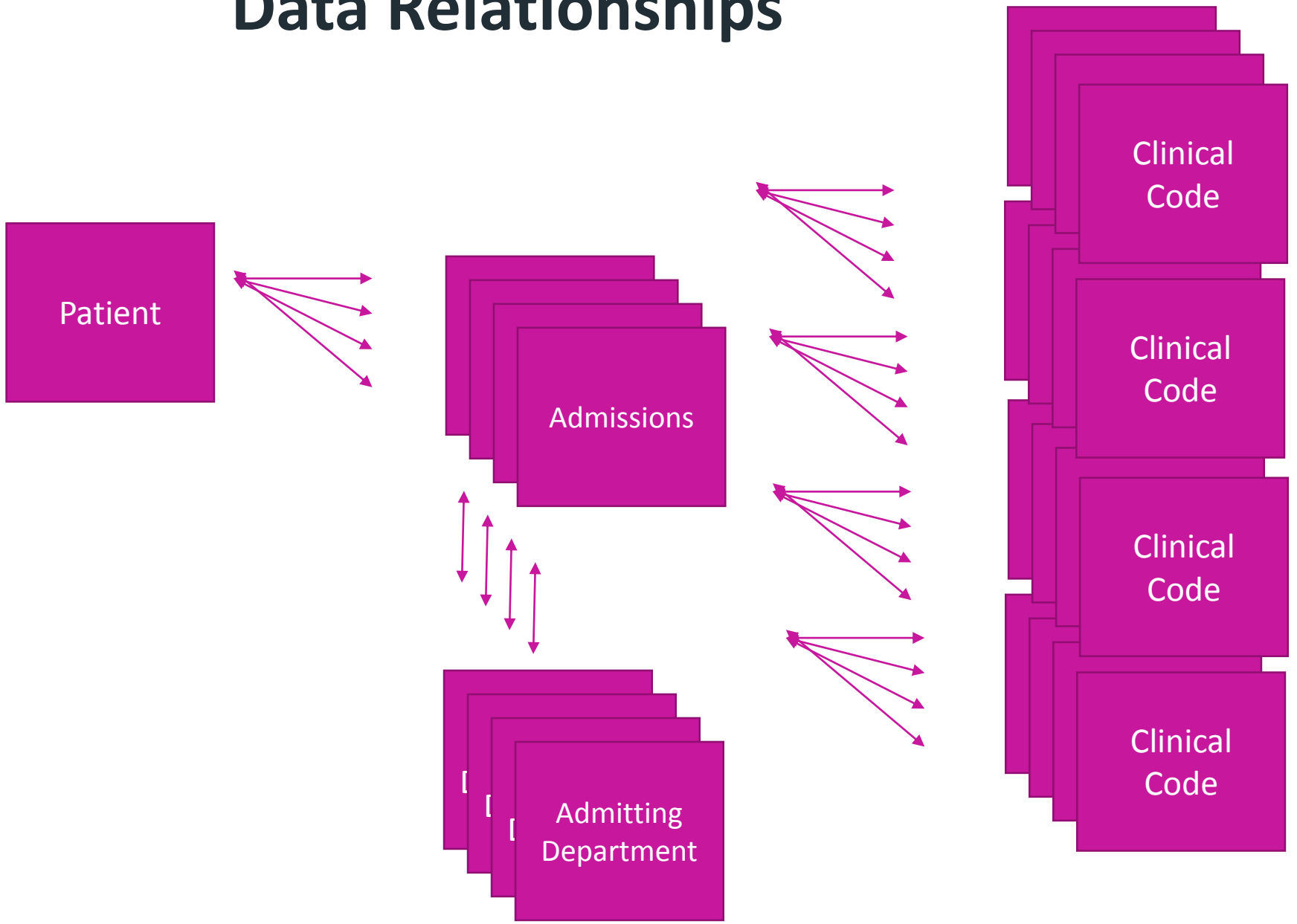
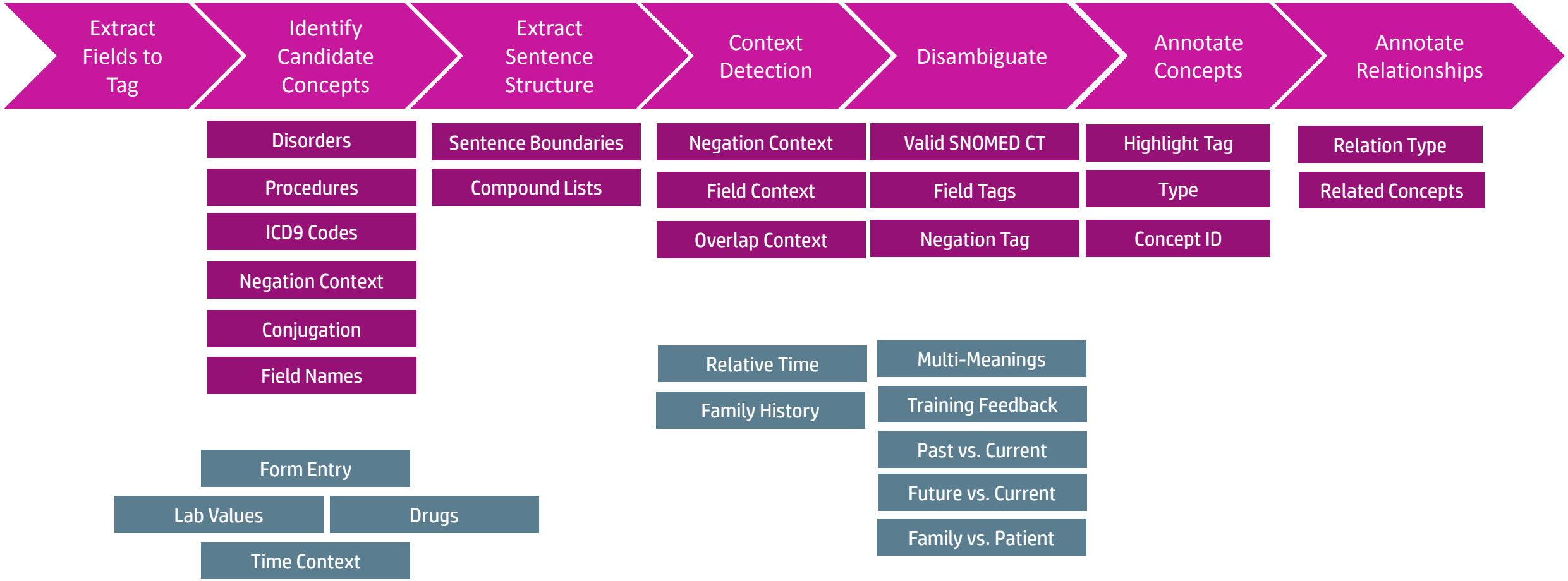
# Data Relationships



# Ontology Tagger Approach

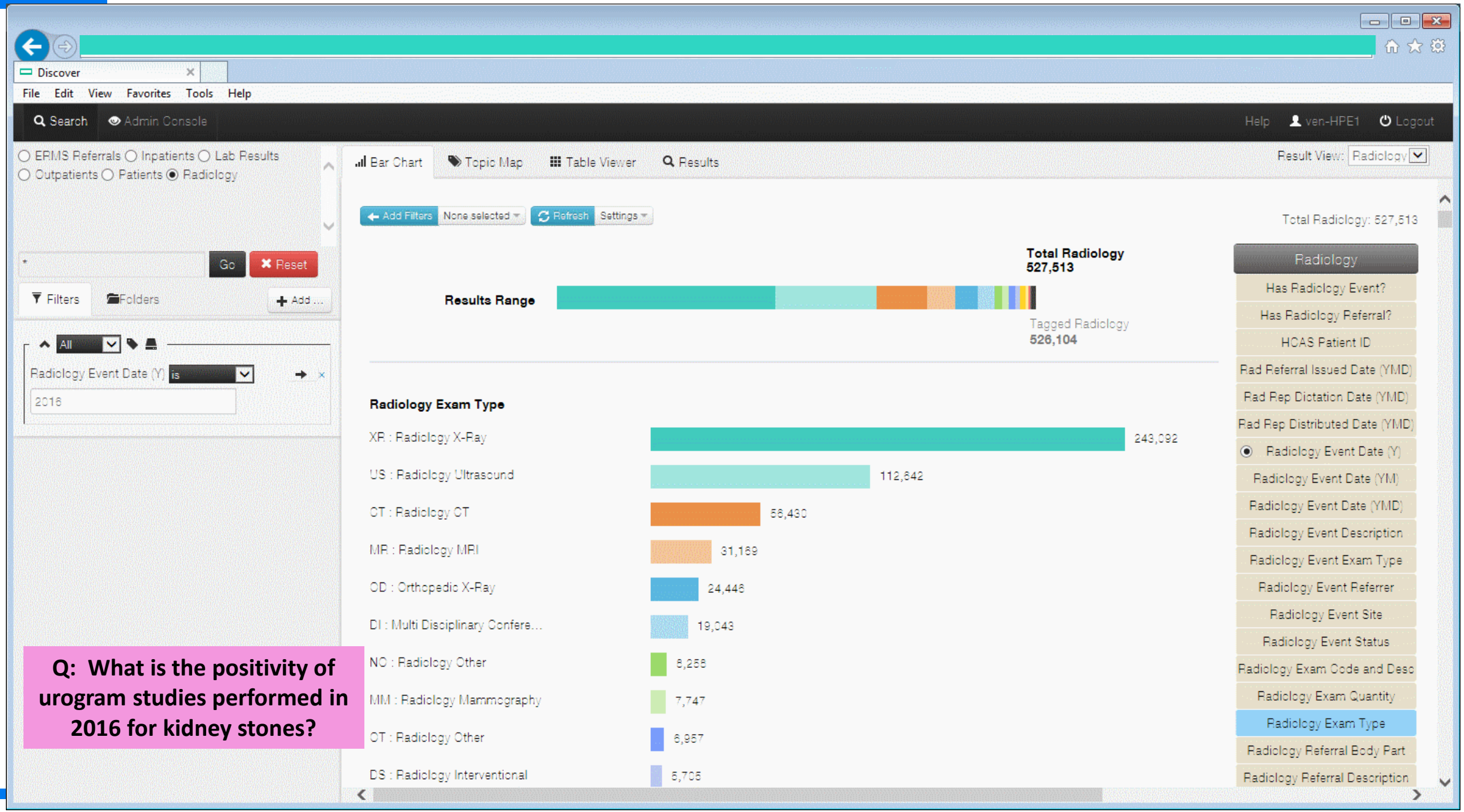


# Example Tagged XML

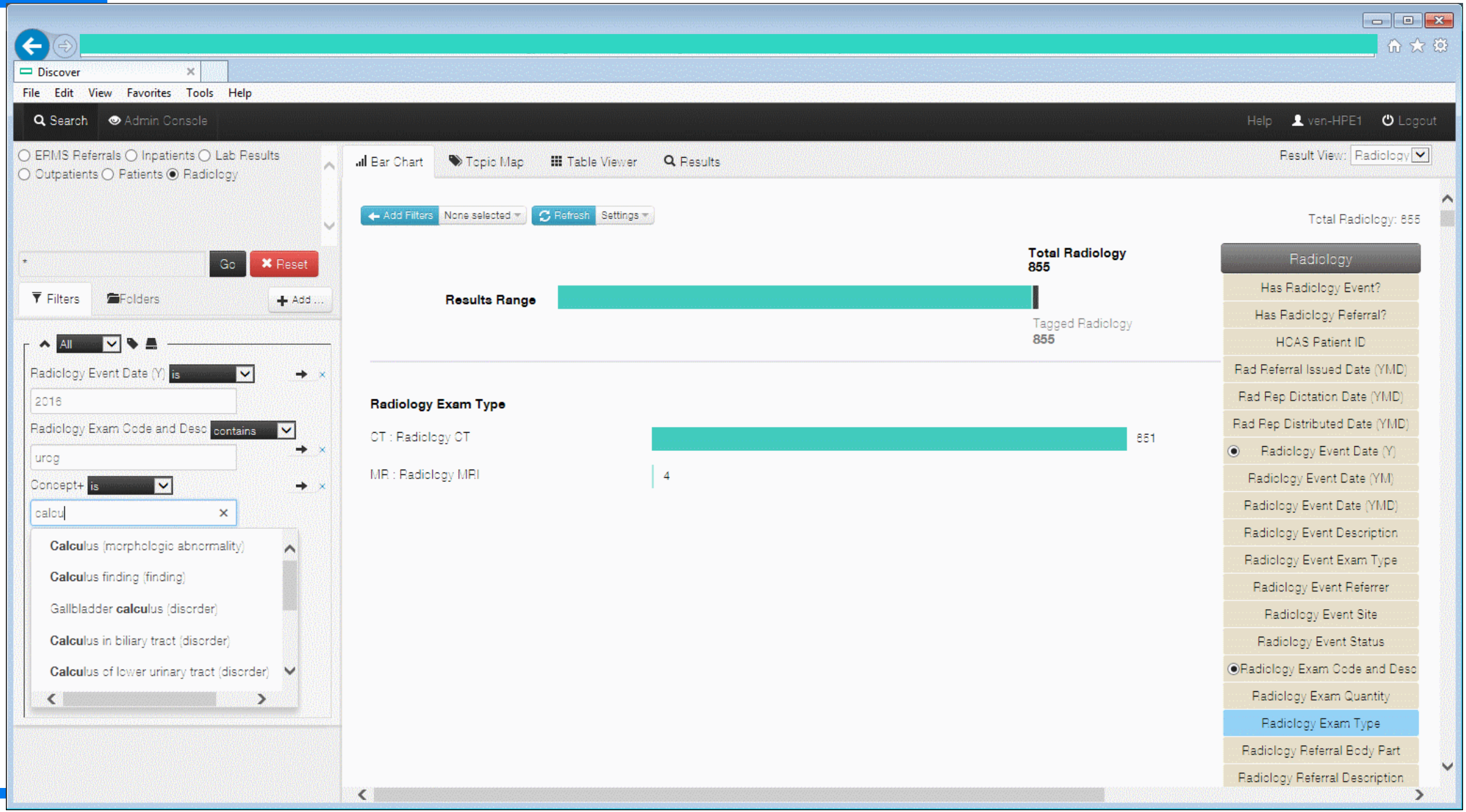
<ICD9>(571.1)ACUTE ALCOHOLIC HEPATITIS</ICD9>
**<ICD9_H>(<H cid='C/SM/9953008'>571.1</H>)**ACUTE ALCOHOLIC HEPATITIS</ICD9_H>

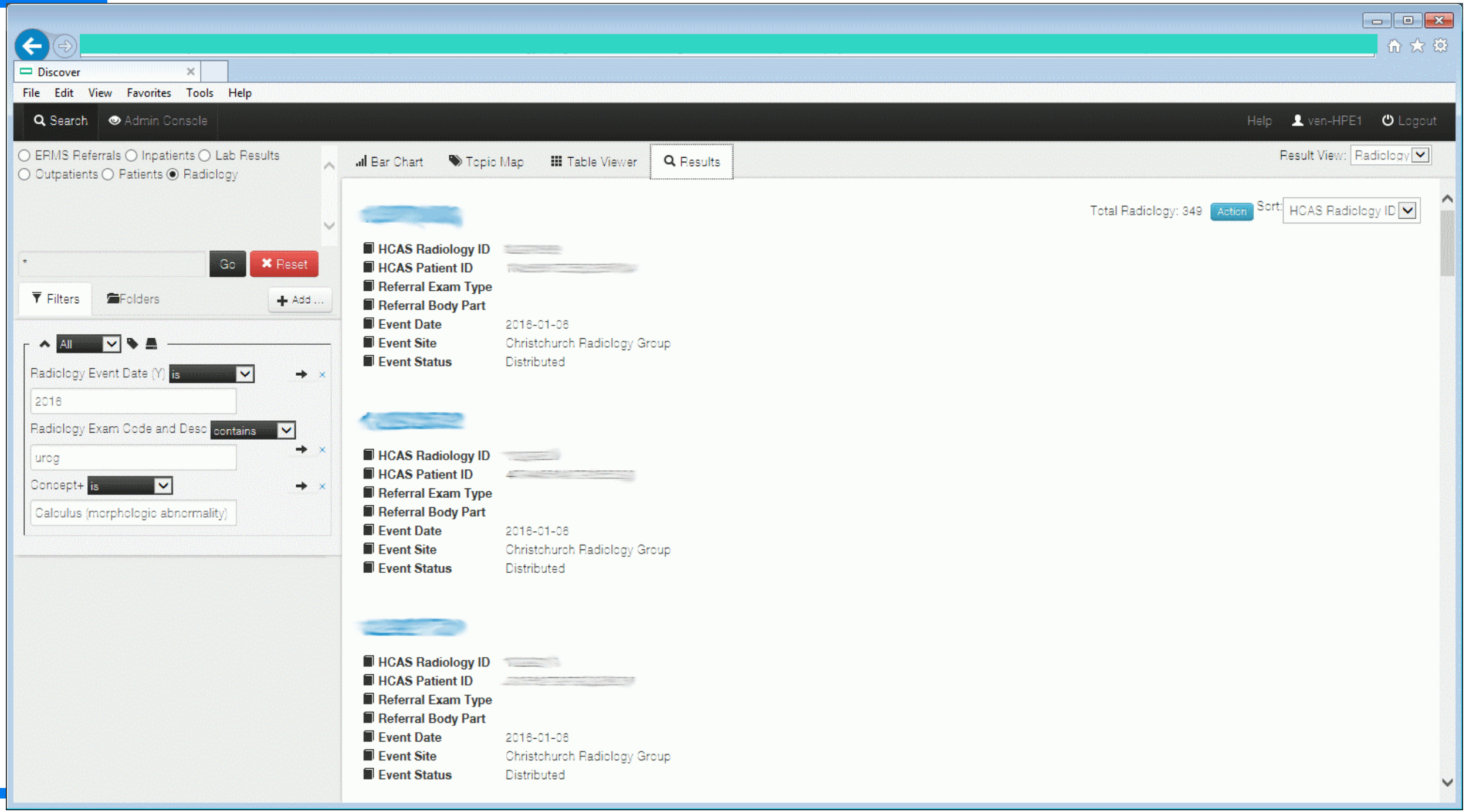
<EVENT>
<NAME>Potassium Chloride</NAME>
**<NAME_H><H cid='C/SM/420155008'><H cid='C/SM/8631001'>Potassium Chloride</H></H></NAME_H>**
<OCCURRENCES>3</OCCURRENCES>
</EVENT>

**<FIELD>INDICATION:</FIELD>** 50-year-old **<H cid='C/SM/10052007'><H cid='C/SM/248153007'>male</H></H>** with ETOH **<H cid='C/SM/417928002'><H cid='C/SM/386702006'>abuse</H></H>** and elevated LFTs. **<FIELD>COMPARISONS:</FIELD>** None**.** **<FIELD>FINDINGS:</FIELD>** Study is extremely limited secondary to patient body habitus. The **<H cid='C/SM/181268008'><H cid='C/SM/10200004'>liver</H></H>** is diffusely echogenic consistent with <H cid='C/SM/45752008'>fatty infiltration</H>. and is <NEG type='PRE'>not</NEG> dilated. Some **<H cid='C/SM/44901006'>sludge</H>** is noted within a mildly distended **<H cid='C/SM/28231008'><H cid='C/SM/181269000'>gallbladder</H></H>.** Mild **<H cid='C/SM/28231008'><H cid='C/SM/181269000'>gallbladder</H></H>** wall ….. He <NEG type='PRE'>denies</NEG> <SM_NEG cid='C/SM/267036007'>dyspnea</SM_NEG>, <SM_NEG cid='C/SM/21522001'>abdominal pain</SM_NEG>




**Q: What is the positivity of urogram studies performed in 2016 for kidney stones?**


Discover
File Edit View Favorites Tools Help
Search
Admin Console
Help
ven-HPE1
Logout
ERMS Referrals
Inpatients
Lab Results
Outpatients
Patients
Radiology
Go
Reset
Filters
Folders
Add ...
All
Radiology Event Date (Y) is
2016
Radiology Exam Code and Desc contains
urog
Concept+ is
calcu
Calculus (morphologic abnormality)
Calculus finding (finding)
Gallbladder calculus (disorder)
Calculus in biliary tract (disorder)
Calculus of lower urinary tract (disorder)
Bar Chart
Topic Map
Table Viewer
Results
Result View: Radiology
Add Filters
None selected
Refresh
Settings
Total Radiology: 855
Total Radiology
855
Results Range
Tagged Radiology
855
Radiology Exam Type
CT : Radiology CT
851
MR : Radiology MRI
4
Radiology
Has Radiology Event?
Has Radiology Referral?
HCAS Patient ID
Rad Referral Issued Date (YMD)
Rad Rep Dictation Date (YMD)
Rad Rep Distributed Date (YMD)
Radiology Event Date (Y)
Radiology Event Date (YM)
Radiology Event Date (YMD)
Radiology Event Description
Radiology Event Exam Type
Radiology Event Referrer
Radiology Event Site
Radiology Event Status
Radiology Exam Code and Desc
Radiology Exam Quantity
Radiology Exam Type
Radiology Referral Body Part
Radiology Referral Description


Discover
File Edit View Favorites Tools Help
Search
Admin Console
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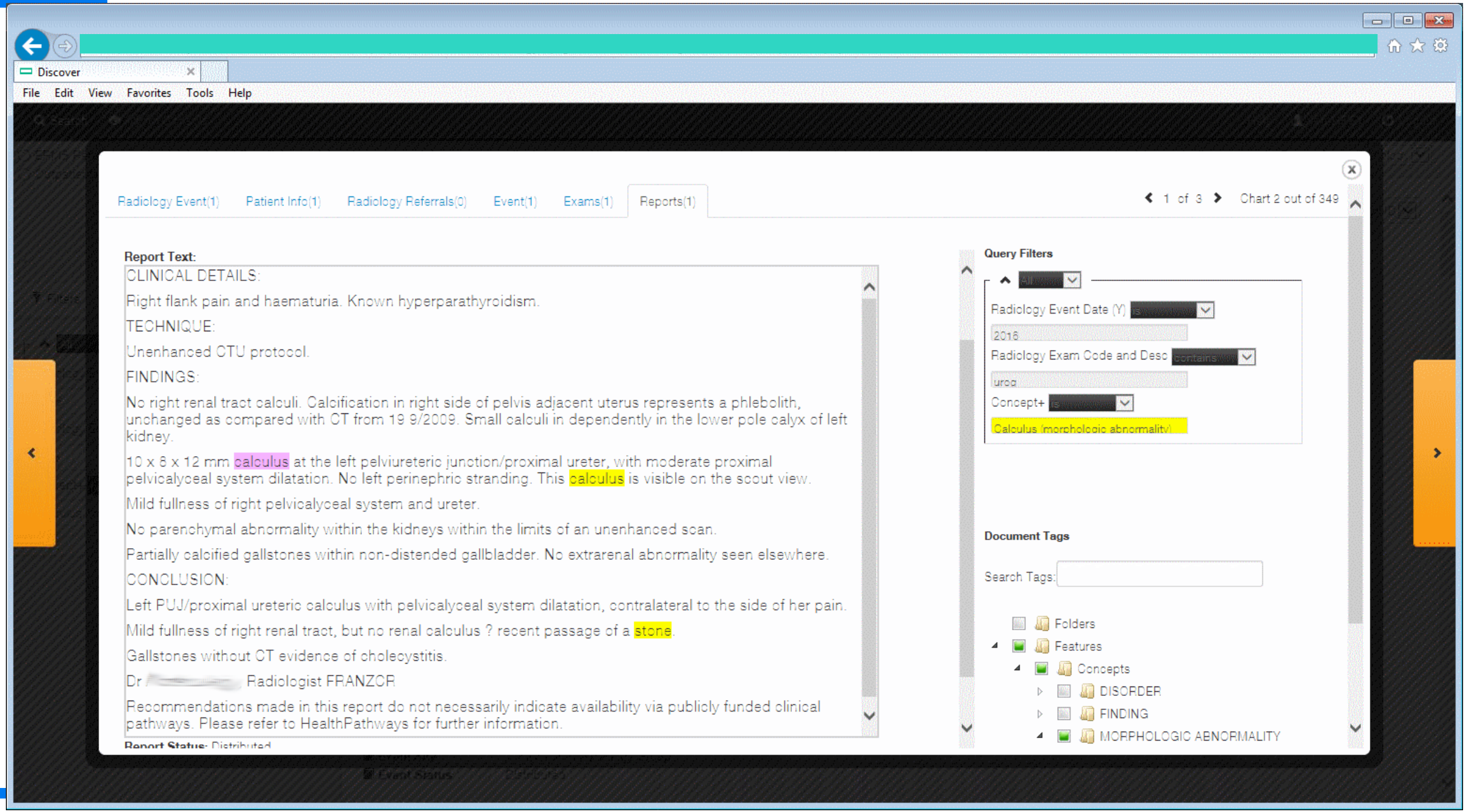
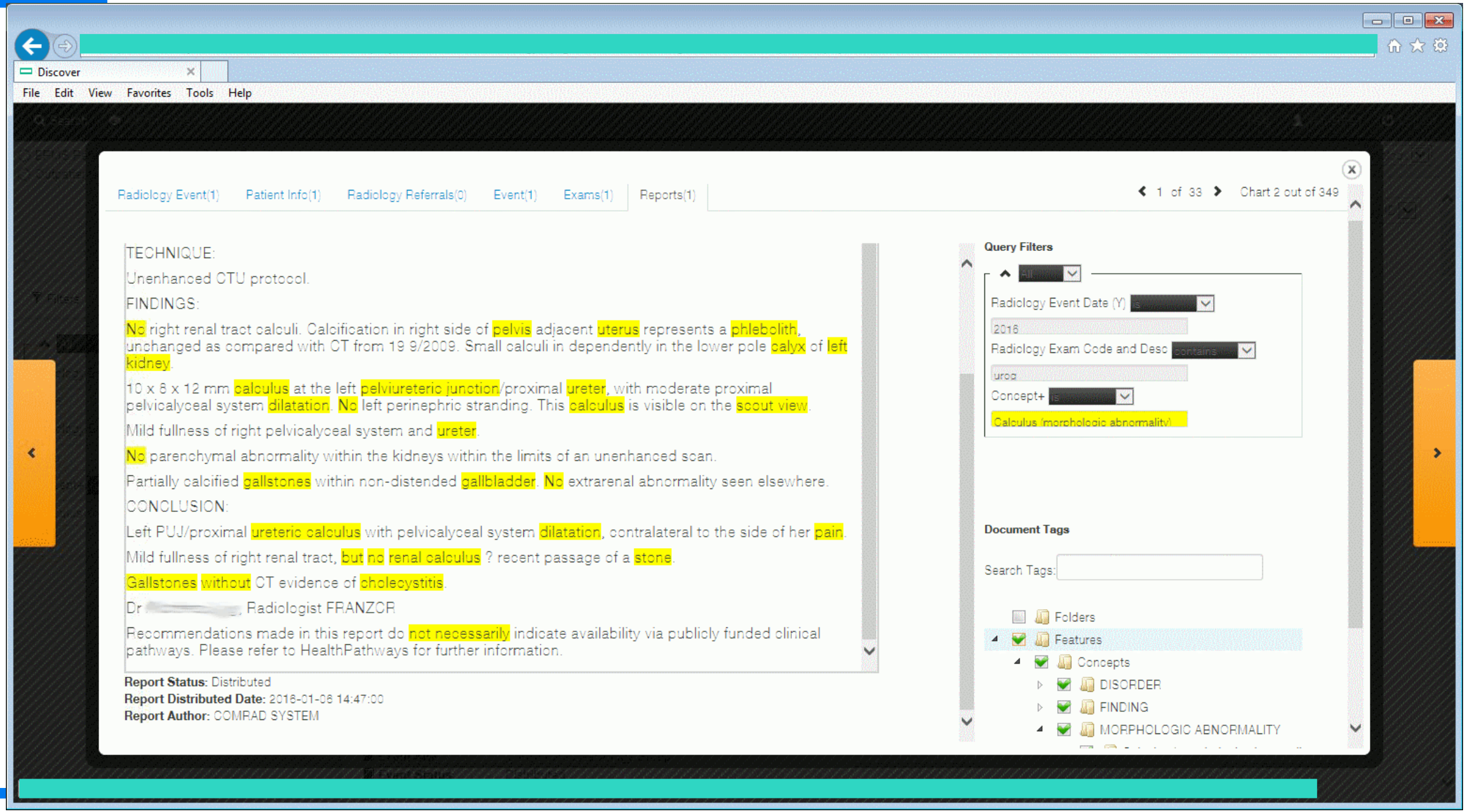
ven-HPE1
Logout
ERMS Referrals
Inpatients
Lab Results
Outpatients
Patients
Radiology
Bar Chart
Topic Map
Table Viewer
Results
Result View: Radiology
Total Radiology: 349
Action
Sort: HCAS Radiology ID
Go
Reset
Filters
Folders
Add ...
All
Radiology Event Date (Y) is
2016
Radiology Exam Code and Desc contains
urog
Concept+ is
Calculus (morphologic abnormality)
HCAS Radiology ID
HCAS Patient ID
Referral Exam Type
Referral Body Part
Event Date 2016-01-06
Event Site Christchurch Radiology Group
Event Status Distributed
HCAS Radiology ID
HCAS Patient ID
Referral Exam Type
Referral Body Part
Event Date 2016-01-06
Event Site Christchurch Radiology Group
Event Status Distributed
HCAS Radiology ID
HCAS Patient ID
Referral Exam Type
Referral Body Part
Event Date 2016-01-06
Event Site Christchurch Radiology Group
Event Status Distributed


Discover
File Edit View Favorites Tools Help
Radiology Event(1)
Patient Info(1)
Radiology Referrals(0)
Event(1)
Exams(1)
Reports(1)
1 of 3
Chart 2 out of 349
Report Text:
CLINICAL DETAILS:
Right flank pain and haematuria. Known hyperparathyroidism.
TECHNIQUE:
Unenhanced CTU protocol.
FINDINGS:
No right renal tract calculi. Calcification in right side of pelvis adjacent uterus represents a phlebolith, unchanged as compared with CT from 19 9/2009. Small calculi in dependently in the lower pole calyx of left kidney.
10 x 8 x 12 mm calculus at the left pelviureteric junction/proximal ureter, with moderate proximal pelvicalyceal system dilatation. No left perinephric stranding. This calculus is visible on the scout view.
Mild fullness of right pelvicalyceal system and ureter.
No parenchymal abnormality within the kidneys within the limits of an unenhanced scan.
Partially calcified gallstones within non-distended gallbladder. No extrarenal abnormality seen elsewhere.
CONCLUSION:
Left PUJ/proximal ureteric calculus with pelvicalyceal system dilatation, contralateral to the side of her pain.
Mild fullness of right renal tract, but no renal calculus ? recent passage of a stone.
Gallstones without CT evidence of cholecystitis.
Dr [redacted] Radiologist FRANZCR
Recommendations made in this report do not necessarily indicate availability via publicly funded clinical pathways. Please refer to HealthPathways for further information.
Report Status: Distributed
Query Filters
Radiology Event Date (Y)
2016
Radiology Exam Code and Desc
urog
Concept+
Calculus (morphologic abnormality)
Document Tags
Search Tags:
Folders
Features
Concepts
DISORDER
FINDING
MORPHOLOGIC ABNORMALITY


Discover
File Edit View Favorites Tools Help
Radiology Event(1) Patient Info(1) Radiology Referrals(0) Event(1) Exams(1) Reports(1)
1 of 33
Chart 2 out of 349
TECHNIQUE:
Unenhanced CTU protocol.
FINDINGS:
No right renal tract calculi. Calcification in right side of pelvis adjacent uterus represents a phlebolith, unchanged as compared with CT from 19 9/2009. Small calculi in dependently in the lower pole calyx of left kidney.
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Dr , Radiologist FRANZCR
Recommendations made in this report do not necessarily indicate availability via publicly funded clinical pathways. Please refer to HealthPathways for further information.
Report Status: Distributed
Report Distributed Date: 2016-01-08 14:47:00
Report Author: COMRAD SYSTEM
Query Filters
Radiology Event Date (Y)
2016
Radiology Exam Code and Desc
urog
Concept+
Calculus (morphologic abnormality)
Document Tags
Search Tags:
Folders
Features
Concepts
DISORDER
FINDING
MORPHOLOGIC ABNORMALITY

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# Text / keyword search and using ontologies

- Report_text CONTAINS “metast”
- Concept+ CONTAINS “metast”
- Concept+ IS “Secondary malignant neoplastic disease (disorder) ”
- Concept IS “Secondary malignant neoplastic disease (disorder) ”

# US SNOMED CT vs NZ SNOMED CT

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## Secondary malignant neoplastic disease (disorder) (128462008)

- CA - Secondary cancer
- Metastases
- Metastatic cancer
- Metastatic malignant disease
- Metastatic neoplasm
- Secondary tumor
- Secondary tumour
- Secondaries
- Secondary cancer
- Secondary malignant deposit
- Secondary malignant neoplastic disease
- Tumor metastasis
- Tumour metastasis
- Metastasis
- Metastatic disease

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calculus Search Reset

Search in: All Hierarchies

All descriptions | Fully Specified Name Only | Concept Identifier

Click here for Advanced search help

***Parent(s):***
***(Select a parent to make it the "Current Concept".)***
Mechanical lesion (morphologic abnormality)

***Current Concept:***
***Calculus (morphologic abnormality)***

***Child(ren):***
***(N=30) (Select a child to make it the "Current Concept".)***
Apatite calculus (morphologic abnormality)
Brushite calculus (morphologic abnormality)
Calcium bilirubinate calculus (morphologic abnormality)
Calcium calculus (morphologic abnormality)
Calcium carbonate calculus (morphologic abnormality)
Calcium oxalate and hydroxyapatite calculus (morphologic abnormality)
Calcium oxalate calculus (morphologic abnormality)
Cholesterol and calcium bilirubinate calculus (morphologic abnormality)
Cholesterol calculus (morphologic abnormality)
Cystine calculus (morphologic abnormality)
Egg concretion (morphologic abnormality)
Faceted calculus (morphologic abnormality)
Fecalith (morphologic abnormality)

***Current Concept:***
**Fully Specified Name:** Calculus (morphologic abnormality)
**ConceptId:** 56381008
**Source:** Core

***Defining Relationships:***
***Is a*** Mechanical lesion (morphologic abnormality)
*This concept's defining relationships are necessary but do not sufficiently define it (a.k.a. primitive).*

***Descriptions (Synonyms):***
**Fully Specified Name:** Calculus (morphologic abnormality)
**Synonym:** Calculus [93755011]
**Synonym:** Concretion [93759017]
**Synonym:** Stone [93760010]
**Synonym:** Calculus, NOS [93756012]
**Synonym:** Concretion, NOS [93757015]
**Synonym:** Stone, NOS [93758013]

***GB English:***
**Preferred:** Calculus [93755011]
**Acceptable:** Concretion [93759017]
**Acceptable:** Stone [93760010]

***US English:***
**Preferred:** Calculus [93755011]
**Acceptable:** Concretion [93759017]
**Acceptable:** Stone [93760010]

**“Calculus” is present**

calculi

Search | Reset

Search in: All Hierarchies

All descriptions | Fully Specified Name Only | Concept Identifier

Click here for Advanced search help

**Parent(s):**
*(Select a parent to make it the "Current Concept".)*

Kidney disease (disorder)
Kidney lesion (finding)
Urolithiasis (disorder)

**Current Concept:**
*Kidney stone (disorder)*

**Child(ren):**
*(N=10) (Select a child to make it the "Current Concept".)*

Calcium renal calculus (disorder)
Calculous pyelonephritis (disorder)
Calculus in renal pelvis (disorder)
Calculus of kidney and ureter (disorder)
Calyceal renal calculus (disorder)
Congenital calculus of kidney (disorder)
Matrix stone of kidney (disorder)
On examination - renal calculus (disorder)
Uric acid renal calculus (disorder)
X-linked recessive nephrolithiasis with renal failure (disorder)

**Current Concept:**

**Fully Specified Name:** Kidney stone (disorder)
**ConceptId:** 95570007
**Source:** Core

**Defining Relationships:**

| | |
|---|---|
| *Is a* | Kidney disease (disorder) |
| *Is a* | Kidney lesion (finding) |
| *Is a* | Urolithiasis (disorder) |
| Group | |
| *Finding site (attribute)* | Kidney structure (body structure) |
| *Associated morphology (attribute)* | Calculus (morphologic abnormality) |

*This concept is sufficiently defined.*

**Descriptions (Synonyms):**

**Fully Specified Name:** Kidney stone (disorder)
**Synonym:** Kidney stone [158296018]
**Synonym:** Renal stone [158297010]
**Synonym:** Nephrolith [158298017]
**Synonym:** Renal calculus [158299013]
**Synonym:** Calculus of kidney [512193015]
**Synonym:** Nephrolithiasis [512194014]
**Synonym:** Kidney calculus [512195010]
**Synonym:** Renal calculi [71011000009116]

**US English:**

**Preferred:** Kidney stone [158296018]
**Acceptable:** Renal stone [158297010]

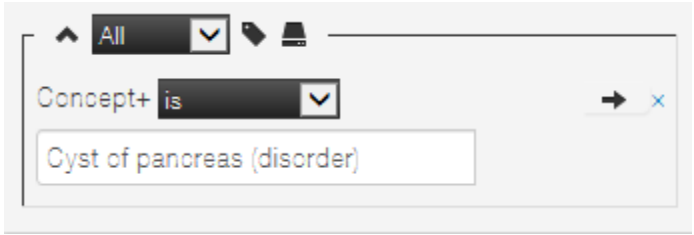
**"Calculi" is absent**

# HCAS Roles in practice

- Rapid hypothesis testing – allowing clinicians and administrators to quickly assemble a cohort of patients to determine whether the data is likely to back-up their hypothesis
- Audit and changes to clinical pathways – significantly faster than manual processes because the system assists in chart abstraction.  Using the same human resources, more auditing can occur, allowing more rapid determination of compliance and the impact of clinical pathway changes.
- Data transparency – Because of the scale of both structured and unstructured data in HCAS, clinicians, administrators, and IT support have new visibility into issues which were difficult or impossible to identify with existing tools.

# Sampling of use-cases in practice

- Radiology study positivity audits
  - CTU for stones in kidney/ureter/bladder
  - Abd CT for pancreatic cysts
- Pathology positivity reports
  - Squamous Cell Carcinoma (and differentiating skin vs lung)
- ICD10 Coding audits
  - Code present but factors not in narrative
  - Factors in narrative but not code present
- Ca surveillance
  - Build dynamic registry based on pattern of hormone Tx, imaging studies



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# Impressions

- Linking data, System validation, Transparency of data
- Breadth of user/use-cases
- Accuracy of search
  - Function of OT processing, clinical note recording, skill of the user
- SNOMED CT implementation
- Importance of training, education, and feedback loops
  - Knowledge of data science
  - Preventing data dredging
  - Thinking about the question *before* using HCAS
- Usability for “intended purpose”

***deploying a solution*** vs ***deploying a technology***



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# Novel aspects

- One of the largest SNOMED CT based systems ( >1B SNOMED CT annotations)
- Functions
  - Real-time cohort generations
  - Computer facilitated chart abstraction
  - Tailored to clinical workflow (collaborative workflow features, save/load queries, save/load results)
- Structured, semi-structured, and unstructured (SNOMED CT, ontologies, mappings)
- Intended to be broadly applicable instead of narrow focus on use-cases (80% utility for 80% of use-cases vs 100% utility for 20% of use-cases)

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# Next steps

- Additional users/use-cases
- HCAS expansion roadmap
- Enterprise system update (Healthcheck)
- Formal benefits analysis
- SNOMED CT feedback based on large scale real-world clinical documentation

# Selected references


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