

Design and validation of automated, customized clinical history searches for imaging interpretation

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Abstract

Clinical practice increasingly relies upon imaging to provide rapid data in the care of patients. While a brief clinical summary often accompanies an imaging request, detailed knowledge of a patient's past medical history can be crucial for optimal study interpretation. Manual electronic record searching is time-consuming and can lead to potentially lower-quality, less-efficient interpretations. We describe here a process for developing customized search queries of the electronic medical record (EMR) built upon the Queriable Patient Inference Dossier (QPID) health record intelligence platform at the Massachusetts General Hospital. Through literature reviews and interviews with referring providers, a list of relevant past medical history search parameters specific to three MR exams (liver, prostate and rectum) was developed. Twenty patient records selected at random were searched across nine liver, prostate and rectum MR search algorithms covering relevant past imaging studies, laboratory values, medications and progress notes. Results indicate that the search system is fast, with an average search time per query of 3.4 ± 1.1 seconds. We also describe a graphical user interface (GUI) that incorporates interpretation guidelines specific to exam type to optimize quality of reports. This study demonstrates the feasibility of constructing automated search queries of a patient EMR which optimize clinical data gathering for use in enhancing speed and quality of image interpretation. Future directions include a demonstration of the accuracy of this tool and its impacts on the efficiency and quality of imaging interpretation.

A history is crucial for image interpretation

A patient history can give insight into potential etiologies of observed imaging anomalies

- ✓ Thus, a short history is often requested alongside an imaging request

Abdomen Indications Active Pt: CLAUIS, SANTA P

Signs & Symptoms and/or Known Diagnoses

210 character limit. Current character count: 0

OK Cancel

Write	View	Transcribe / RN Review	Cosign	Ack	Desensitize Medication	Activate	Special Orders	Reprint Labels	Chemo Options
Post-OP Surgeon	Post-OP Anesthesia	Face Sheet Discharge		Nursing Orders	Day of Procedure	eMAR Tools	Pre-Admit Med List	Tools	Refresh

Index:

Chemistry & Toxicology	23-Oct-2013			
MGR	23-Oct-2013 12:18	Accession#	1023W0101	
MGR	15-Oct-2013 11:36	Accession#	1016T44475	
MGR	10-Oct-2013 10:04	Accession#	1010H62559	
MGR	01-Oct-2013 09:31	Accession#	1002T26716	
MGR	13-Sep-2013 12:41	Accession#	0913F28813	
MGR MISCELLANEOUS	09-Aug-2013 10:00	Accession#	0809F58721	
MGR BLOOD	25-Jul-2013 18:10	Accession#	0725H46365	
MGR CMC SPECIMEN	25-Jul-2013 17:00	Accession#	0725H46121	
MGR CMC SPECIMEN	25-Jul-2013 17:00	Accession#	0725H46145	
MGR	25-Jul-2013 15:03	Accession#	0806H57032	
MGR	25-Jul-2013 14:53	Accession#	0806H57031	
MGR	25-Jul-2013 14:43	Accession#	0806H57030	
MGR	23-Jul-2013 13:21	Accession#	0806T20472	
MGR	23-Jul-2013 11:25	Accession#	0806T20194	
MGR	23-Jul-2013 11:15	Accession#	0806T20193	

Detail:

Print

But, manual EMR searching for additional information is slow

- ✓ The needed data could be hidden among hundreds of past imaging studies, notes or laboratory results
- ✓ ...which could take excess time and effort to uncover

The QPID interface allows for EMR searching

QPID (Queriable Patient Inference Dossier) is a Massachusetts General Hospital health record intelligence platform that allows for automated, customized searches of the electronic medical record.

QPID EMR MRN/Name: 0000004 MGH Go Last 25 Options Apps Help Feedback

CLAUDIA, SANTA N 64/M Search this patient Go Help

Sort by type Sort by date

Endoscopy Reports - NDO (127)
12/15/2012 MGH [Colonoscopy](#)
04/05/2012 BWH [Colonoscopy](#)
06/30/2011 MGH [Endoscopy Report](#)
[More](#)

LMR Notes - NTE (5210)
10/25/2013 MGH [Result Manager Letter](#)
10/25/2013 MGH [Result Manager Letter](#)
10/25/2013 MGH [Result Phone Call](#)
[More](#)

OnCall Medications - OMED (1)
10/29/2013 MGH [OnCall Medication List](#)

Operative Reports - OPN (58)
12/25/2012 MGH [OP NOTE](#)
10/26/2012 MGH [OP NOTE](#)
05/24/2012 MGH [OP NOTE](#)
[More](#)

Pathology Reports - PAT (230)
06/10/2013 MGH [Surgical Pathology](#)
05/31/2013 MGH [Surgical Pathology](#)
05/31/2013 MGH [Surgical Pathology](#)
[More](#)

EMEDS Pre-Admission Medication List (PAML) - PHED (1)
10/29/2013 PHS [PAML Medication List](#)

LMR Problems - PROB (1)
10/29/2013 PHS [LMR Problem List](#)

Radiology Reports - RAD (403)
10/31/2012 MGH [Dexa Spine 8/or Hip](#)
09/04/2012 MGH [Outside - US Lower Ext Non Vascular](#)
08/30/2012 MGH [Outside - RF Lower Extremity](#)
[More](#)

Scanned Reports - SCN (14)
08/06/2013 MGH [Neurology Report:Scanned](#)
08/04/2013 MGH [Cardiology Report:Scanned](#)
08/02/2013 MGH [Audiology Report:Scanned](#)
[More](#)

LMR Vital Signs - VTL (1)
10/29/2013 PHS [LMR Vital Signs](#)

HEM	08/07/2013	PT	...Credit...	1 result for 'pt type:HEM last:1'
HEM	06/21/2013	APTT	...26.1...	1 result for 'aptt type:HEM last:1'
HEM	06/28/2013	PLT	...296...	1 result for 'plt type:HEM last:1'
HEM	07/26/2013	WBC Screen POCT	...Negative...	1 result for '[(wbc and turba) type:HEM last:1]
CHM	06/17/2013	Plasma Urea Nitrogen	...7...	1 result for '["Plasma Urea Nitrogen" type:CHM last:1]
HEM	08/07/2013	PT-INR	...Credit...	1 result for '["PT-INR" type:HEM last:1]
CHM	06/17/2013	Plasma Creatinine	...0.65...	1 result for '["Plasma Creatinine" type:CHM last:1]
PROB	05/23/2013	Hypertensive disorder	--	16 results for 'type:PROB'
PROB	10/03/2012	Cardiac pacemaker	...Please print this for the gray chart...	
PROB	11/12/2010	Acne	--	
PROB	07/02/2009	Endoscopy	--	
PROB	10/06/2008	Eczema	--	
ALRG	10/20/2013	CYCLOPHOSPHAMIDE		1 result for 'type:ALRG'
LMED	10/28/2013	ATENOLOL	...Atenolol 50 MG (50 MG TABLET Take 1) PO QD x 60 days...	3 results for 'type:LMED'
LMED	09/06/2013	LIPITOR (ATORVASTATIN)	...Lipitor (ATORVASTATIN) 10 MG (10 MG TABLET Take 1) PO QHS x 30 days...	
LMED	08/08/2013	TETRACAINE 1%	...Tetracaine 1% 10 MG (10 MG/ML AMPUL Take 1 ML) INTRATHECAL x1 x 30 days...	

The QPID interface allows for EMR searching

A natural language processing (NLP) platform allows for meaningful EMR searching via pre-written search queries or via a built-in search query language.

- ✓ “*malignancy” searches for results associated with cancer, carcinomas, masses, etc.
- ✓ “*type_meds and lisinopril” searches for the drug lisinopril only within medication lists.

The screenshot displays the QPID EMR interface. At the top, the header includes the QPID EMR logo, a patient MRN/Name field (0000004), a dropdown menu (MGH), and a Go button. Navigation links for 'Last 25', 'Options', 'Apps', 'Help', and 'Feedback' are also present. Below the header, the patient name 'CLAUS, SANTA N 64/M' is shown, along with a search bar containing 'mri' and a Go/Help button. The main content area is divided into two panes. The left pane, titled 'Sort by type' and 'Sort by date', lists various report categories with counts and links to view more details: Endoscopy Reports - NDO (127), LMR Notes - NTE (5210), OnCall Medications - OME (1), Operative Reports - OPN (58), Pathology Reports - PAT (230), EMEDS Pre-Admission Medication List (PAML) - PMED (1), LMR Problems - PROB (1), Radiology Reports - RAD (403), Scanned Reports - SCN (14), and LMR Vital Signs - VTL (1). The right pane displays a list of search results for 'mri', showing 121 results. Each result entry includes a date, report type, and a brief description of the finding, with 'MRI' highlighted in yellow. Examples include: '03/07/2013 Pediatric Pre-Anesthesia Screening Phone Call ... prior anesthesia, list Date(s) and Procedure(s) MRI, 10/18/2012 Problems with prior anesthesia No Coping ...', '02/05/2013 ED Discharge Summary ...-rays were performed. A CT scan was performed. An MRI was performed. You were given medications for pain. You were given...', '12/21/2011 North (Pole) Neurosurgery Consult Note ...f other acute intracranial pathology. A follow-up MRI w/ gadolinium confirmed the presence of the hypothalamic mass and ...', '07/28/2011 Result Phone Call ...ensity CAT Scan Cervical Culture Mammogram normal MRI Other Pap Smear Stool Card Test Ultrasound Urine Culture Vaginal C...', '02/24/2011 Outside - MRI Spine Bone ... Report Status: Final Type: Outside - MRI Spine Bone Date/Time: 02/24/2011 13:06 Exam Code: MRISPIBOLI Ord...', '02/04/2011 Outside - MRI Spine ... Report Status: Final Type: Outside - MRI Spine Date/Time: 02/04/2011 08:06 Exam Code: MRISPINELI Ordering...', '10/18/2010 Outside - MRI Abdomen ... Report Status: Final Type: Outside - MRI Abdomen Date/Time: 10/18/2010 10:13 Exam Code: MRIABLI Ordering ...', '07/12/2010 NEW ... consideration of epo. 4.) Sleep study. 5.) Brain MRI. 6.) A1C today and follow up in 3 months for diabetes check. 7.) A...', '03/09/2010 Outside - MRI Brain ... Report Status: Final Type: Outside - MRI Brain Date/Time: 03/09/2010 11:00 Exam Code: MRIBRNLI Ordering P...', '01/01/2010 RETURN ...alth Alliance. He would like me to order a brain MRI given patient's history of memory difficulty and delirium. Have r...', '07/09/2009 MRI ... Note Status: Final Date: 07/09/09 Reviewed MRI results with patient and explained Results Radiology 0...', '04/24/2009 MRI Knee W/O Con ... Report Status: Final Type: MRI Knee W/O Con Date/Time: 04/24/2009 08:00 Exam Code: MRKNE- Order...', '03/17/2009 Radiology ...med separately. IMPRESSION: MRI performed for research purposes. RADIOLOGISTS: ...', '02/12/2009 Patient Note ...onary artery disease ? Herniated disc : schedule MRI, pt interested in acupuncture also abuse Acne ESOPHAGEAL VARICES ...', '02/09/2009 Referral ...ery disease ? Herniated disc : schedule MRI, pt interested in acupuncture also abuse Acne ...', '02/09/2009 Referral ...ery disease ? Herniated disc : schedule MRI, pt interested in acupuncture also abuse Acne ...', '02/04/2009 Discharge Summary ...Neuropsychologic testing, Ink Blot testing, Brain MRI ALLERGIES NKA: No Known Allergies HISTORY AND REASON FOR HOSPITA...', '01/29/2009 Follow Up Visit ...ery disease ? Herniated disc : schedule MRI, pt interested in acupuncture also abuse Acne ...', '01/29/2009 Physical Exam ...ery disease ? Herniated disc : schedule MRI, pt interested in acupuncture also abuse Acne ...', '01/17/2009 Patient Note ...onary artery disease ? Herniated disc : schedule MRI, pt interested in acupuncture also abuse ...'

Search queries were designed for MR studies

Liver, prostate and rectal magnetic resonance (MR) imaging studies were selected based on the complexity of their interpretation and the utility of additional medical record data in informing the interpretation

Search queries were designed to encompass, among others

- ✓ Past imaging studies
- ✓ Laboratory results
- ✓ Medication and allergy lists
- ✓ Pathology results
- ✓ Operative and procedural notes
- ✓ Admission, progress and discharge notes, as well as other unstructured notes

Nine parameters were searched for liver studies, twelve for prostate studies and seven for rectal studies

Search queries were designed for MR studies

Example search queries include

*MR_liver_meds =

No results for '(*type_meds and ("Ortho Novum" or "Trivora" or "Loestrin" or "apri" or "aranelle" or "aviane" or "balziva" or "brevicon" or "caziant" or "cryselle" or "cyclessa" or "desogen" or "enpresse" or "estrostep" or "femcon" or "gianvi" or "jolessa" or "junel" or "kariva" or "kelnor" or "leena" or "lessina" or "levora" or "loestrin" or "lo/ovral" or "loseasonique" or "low-ogestrel" or "lutra" or "lybrel" or "microgestin" or "mircette" or "modicon" or "mononessa" or "necon" or "nordette" or "norinyl" or "nortrel" or "ocella" or "ogestrel" or "ortho-cept" or "ortho-cyclen" or "orthocyclen" or "ortho-novum" or "ortho tri-cyclen" or "orthotricyclen" or "ovcon" or "portia" or "quasense" or "reclipsen" or "seasonale" or "solia" or "sronyx" or "tri-legest" or "tri-norinyl" or "tri-previfem" or "tri-sprintec" or "trivora" or "velivet" or "yasmin" or "yaz" or "zenchent" or "zovia" or "amiodarone")) or (type:nite and ("contraception" or "amiodarone" or "birth control pills" or "oral contraceptives" or "ocps"))'

*MR_prostate_path =

2 results for '(type:pat and title:"surgical pathology" and (prostate or prostatic or gleason)) or (type:pat and title:"cytology" and ("urine" or "prostate")) or (type:rad and title:"biopsy")'

*MR_rectal_notes =

6 results for 'type:nite and last:6 and (rectum or rectal)'

A GUI displayed search results and image interpretation guidelines

POWERED BY [OPID](#) Last computed at: 10/30/13 9:42 AM [Refresh](#) Search this patient [Go](#) [Help](#) [Feedback](#)

Prior Pathology and Imaging	Labs and Medications	Keywords and Notes	Prostate MRI RadAdvisor
Gleason Pathology MRI CT Bone Scan	PSA UA INR Prostate Meds	Prostate related issues Malignancy Prior Notes	Report 4 critical pieces of information: <ul style="list-style-type: none">• Sites of tumor• Presence of extracapsular extension• Involvement of nodes• Metastases (osseous involvement, uretral involvement, or bladder base) Information to gather prior to intrepretation: <ul style="list-style-type: none">• Date of biopsy• Location of tumor on biopsy• PSA level (<10 low risk, 10-20 moderate risk, >20 high risk)• Gleason and pathologic score (6-low risk, 7-moderate risk, 8-high risk) Implications of staging: <ul style="list-style-type: none">• T1 or T2 (confined to prostate) -radical prostatectomy• T3a (extracapsular extension)• T3b (seminal vesicle invasion) -XRT and Brachytherapy• T4 (invasion of adjacent structures) - Palliative treatment with hormonal or XRT Specificity is more important than sensitivity to prevent patients from being excluded from potentially curative treatment 4 screen view: <ul style="list-style-type: none">• T1W (to detect hemorrhage from prior biopsy)• T2W (to detect tumor which is typically low signal on T2)• ADC map (to detect abnormal diffusion)• DCE (to detect abnormal blood perfusion) Common pitfalls on T2: Wedge shaped low intensity lesions - DDx <ul style="list-style-type: none">• Chronic granulomatous prostatitis• Hemorrhage• Atrophy Tumors typically have ill defined margins on T2 weighted images Most specific signs of extracapsular extension: <ul style="list-style-type: none">• Asymmetry of the neurovascular bundle• Blunting of the rectoprostatic angle• Direct tumor extension outside of capsule Nodal involvement (> 7mm): Obturator, Internal iliac, External iliac. *Common iliac node involvement equates to distant metastases

Prior pathology and imaging results

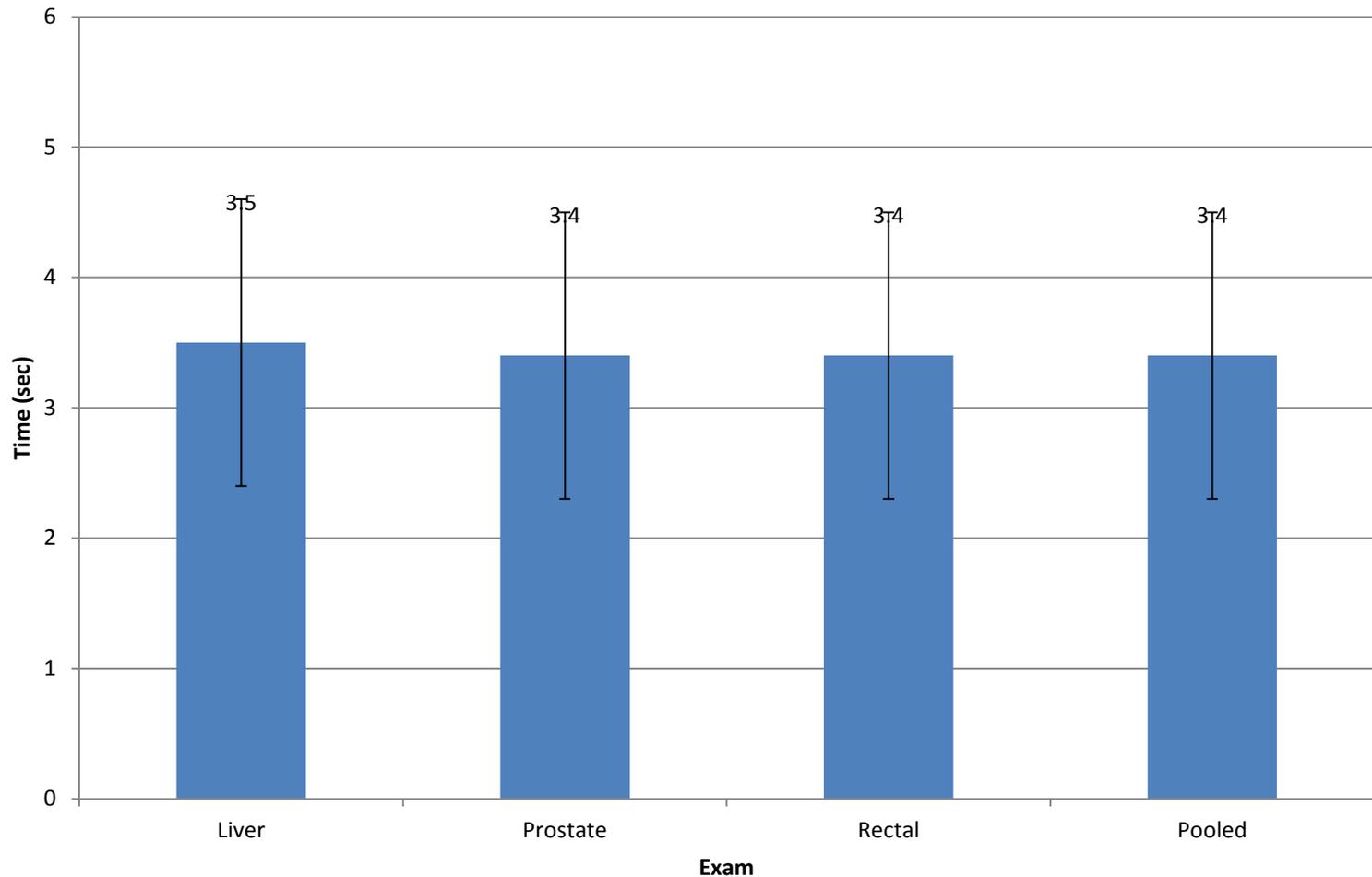
Relevant lab results and medications

Note keyword results

Interpretation guidelines

Search queries were fast

Pooled search and GUI display time was 3.4 ± 1.1 seconds.



Search results were manually reviewed

Two authors (S. G. and A. K.) independently reviewed search query results for accuracy, and an online system allowed for review and calculation of positive and negative predictive values.

N	Sensitivity	Specificity	PPV	NPV
20	0.57142857142857	1	1	0.8125
	4 / (4 + 3)	13 / (13 + 0)	4 / (4 + 0)	13 / (13 + 3)

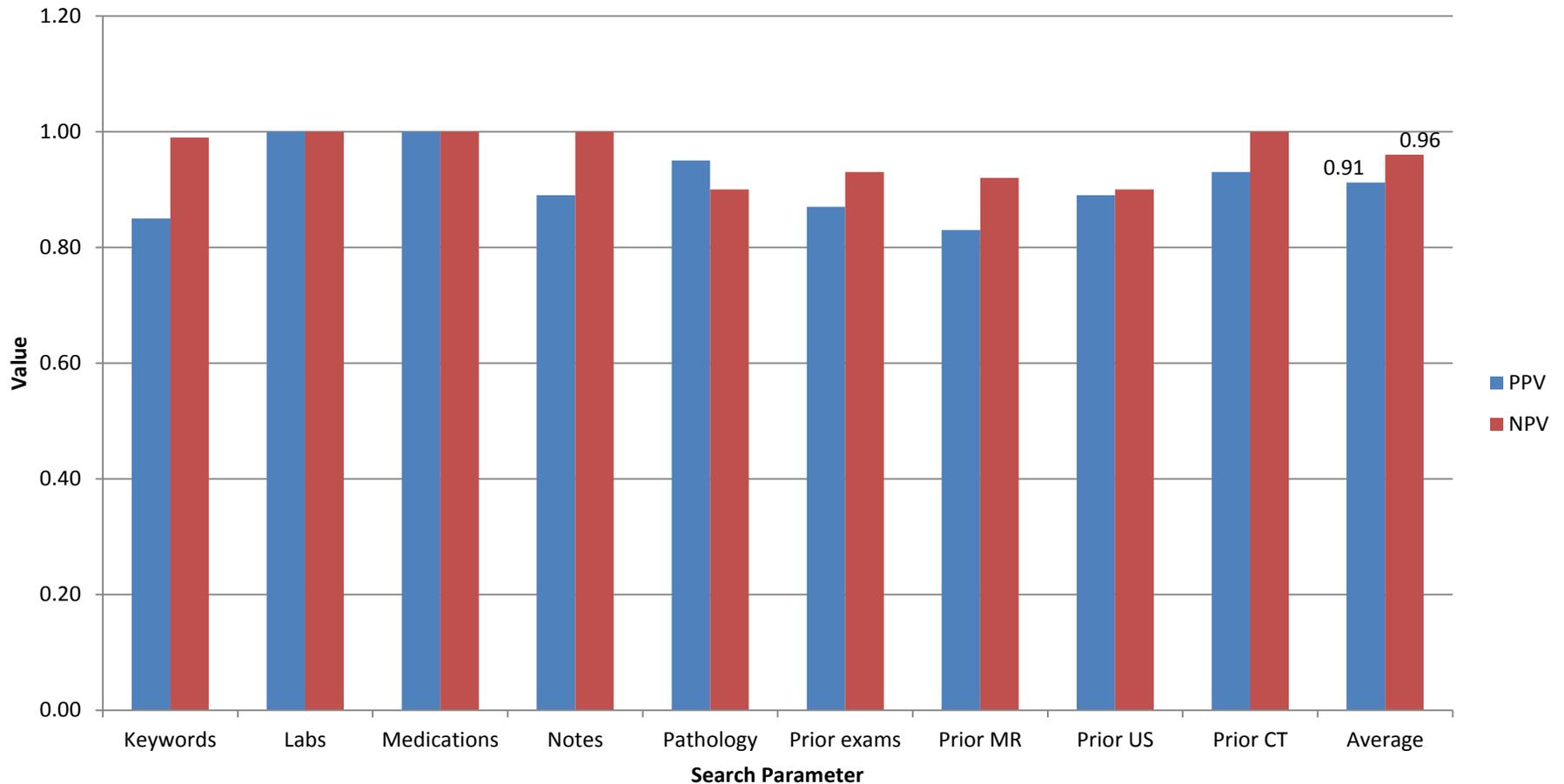
Hits	Context	Actions
YES	Exam Number: 14524088 Report Status: Final Ty	<input checked="" type="radio"/> Yes <input type="radio"/> No <input type="button" value="Reset"/> Comment: <input type="text"/>
YES	Exam Number: 14342359 Report Status: Final Ty Exam Number: 14071463 Report Status: Final Ty Exam Number: 13938643 Report Status: Final Ty	<input checked="" type="radio"/> Yes <input type="radio"/> No <input type="button" value="Reset"/> Comment: <input type="text"/>
YES	Exam Number: 14370779 Report Status: Final Ty	<input checked="" type="radio"/> Yes <input type="radio"/> No <input type="button" value="Reset"/> Comment: <input type="text"/>
YES	Exam Number: 14545619 Report Status: Final Ty	<input checked="" type="radio"/> Yes <input type="radio"/> No <input type="button" value="Reset"/> Comment: <input type="text"/>
NO		<input type="radio"/> Yes <input checked="" type="radio"/> No <input type="button" value="Reset"/> Comment: <input type="text"/>
NO		<input checked="" type="radio"/> Yes <input type="radio"/> No <input type="button" value="Reset"/> Comment: <input type="text" value="12/09/08"/>
NO		<input type="radio"/> Yes <input checked="" type="radio"/> No <input type="button" value="Reset"/> Comment: <input type="text"/>
NO		<input type="radio"/> Yes <input checked="" type="radio"/> No <input type="button" value="Reset"/> Comment: <input type="text"/>
NO		<input type="radio"/> Yes <input checked="" type="radio"/> No <input type="button" value="Reset"/> Comment: <input type="text"/>
NO		<input type="radio"/> Yes <input checked="" type="radio"/> No <input type="button" value="Reset"/> Comment: <input type="text"/>
NO		<input type="radio"/> Yes <input checked="" type="radio"/> No <input type="button" value="Reset"/> Comment: <input type="text"/>

Cohen's κ was selected as a conservative measure of inter-observer agreement.

✓ $\kappa = 0.90$, indicating a high degree of agreement

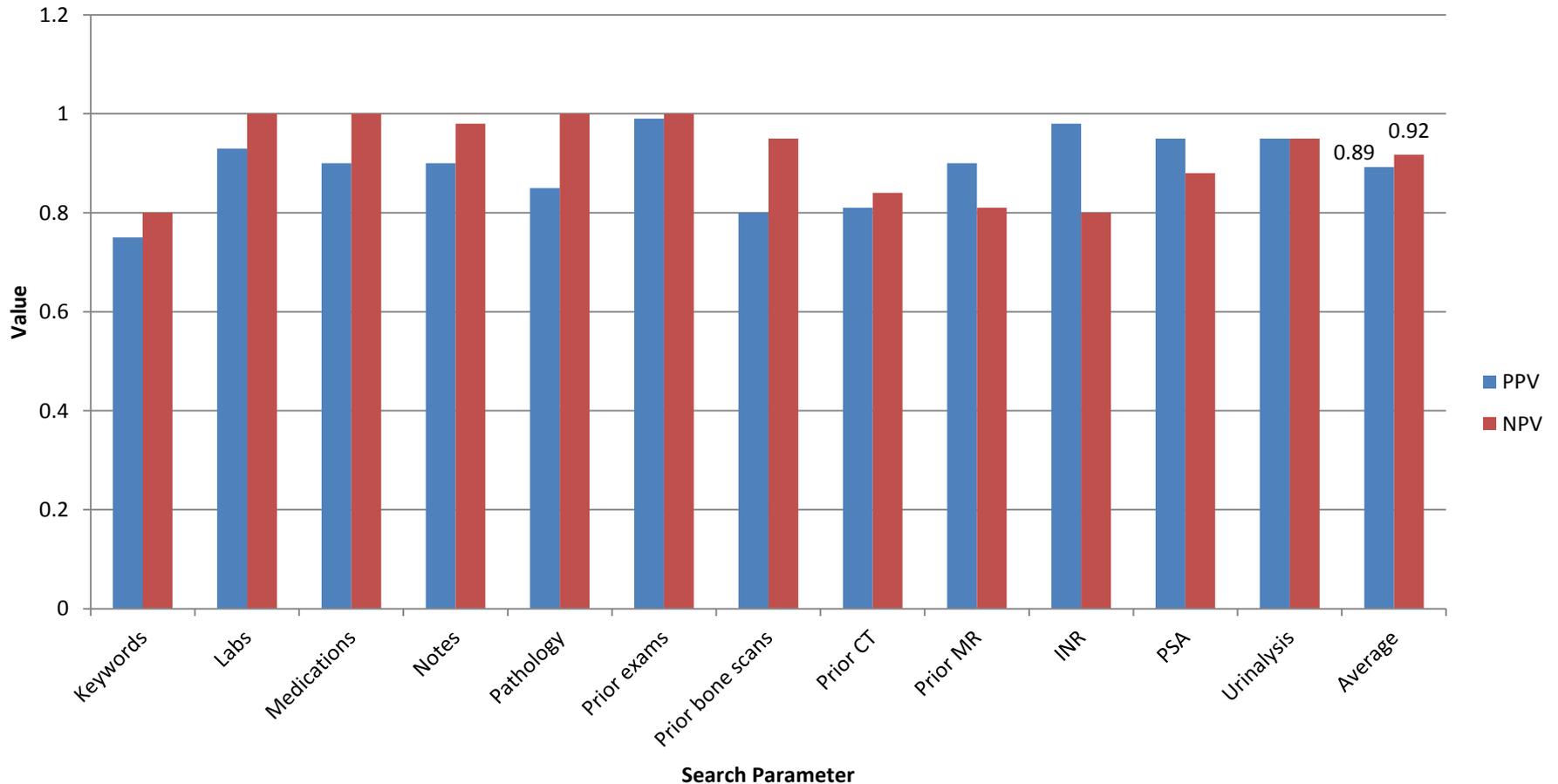
Liver MR searches showed high PPVs, NPVs

Liver MR



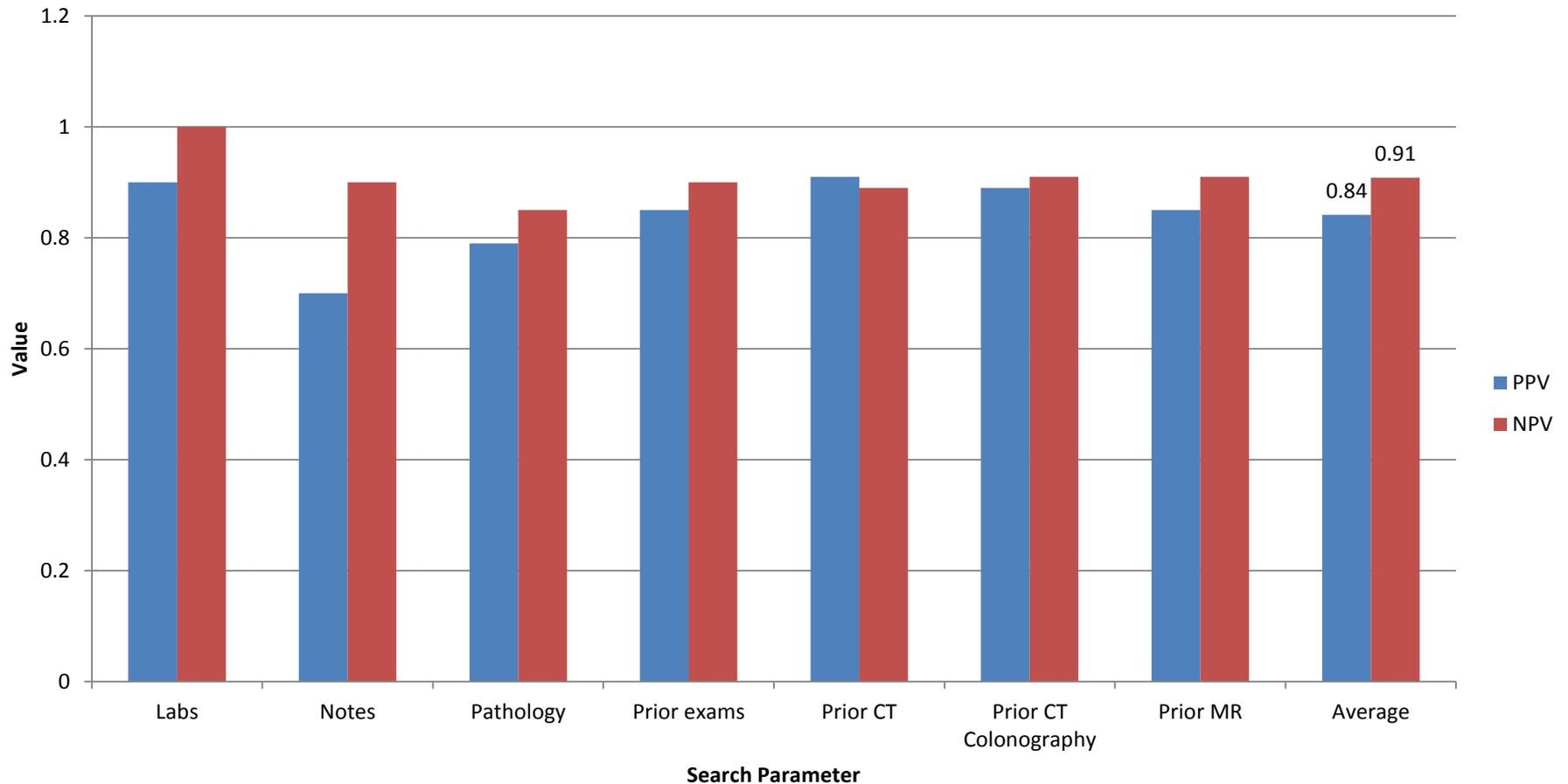
Prostate MR searches showed similar results

Prostate MR



Rectal MR searches showed similar results

Rectal MR



Pooled PPV and NPV was high

$$\text{PPV}_{\text{all exams, all searches}} = \mathbf{0.86 \pm 0.02}$$

$$\text{NPV}_{\text{all exams, all searches}} = \mathbf{0.91 \pm 0.01}$$

Automated search queries have the potential to optimize radiology clinical data gathering

Searching

- Pertinent patient historical data to the radiologist can be distilled and converted to search queries to automate EMR searching.
- Searches are fast and accurate

Display

- A graphical user interface (GUI) can display uncovered data for the convenience of the radiologist.

Future

- Studies are underway to assess the impacts of automated searches on speed of image interpretation and on quality of resulting report.

Questions?

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