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

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.

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.

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 "lutera" 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:nte 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:nte and last:6 and (rectum or rectal)'

A GUI displayed search results and image interpretation guidelines

Search queries were fast

Pooled search and GUI display time was 3.4 ± 1.1 seconds.
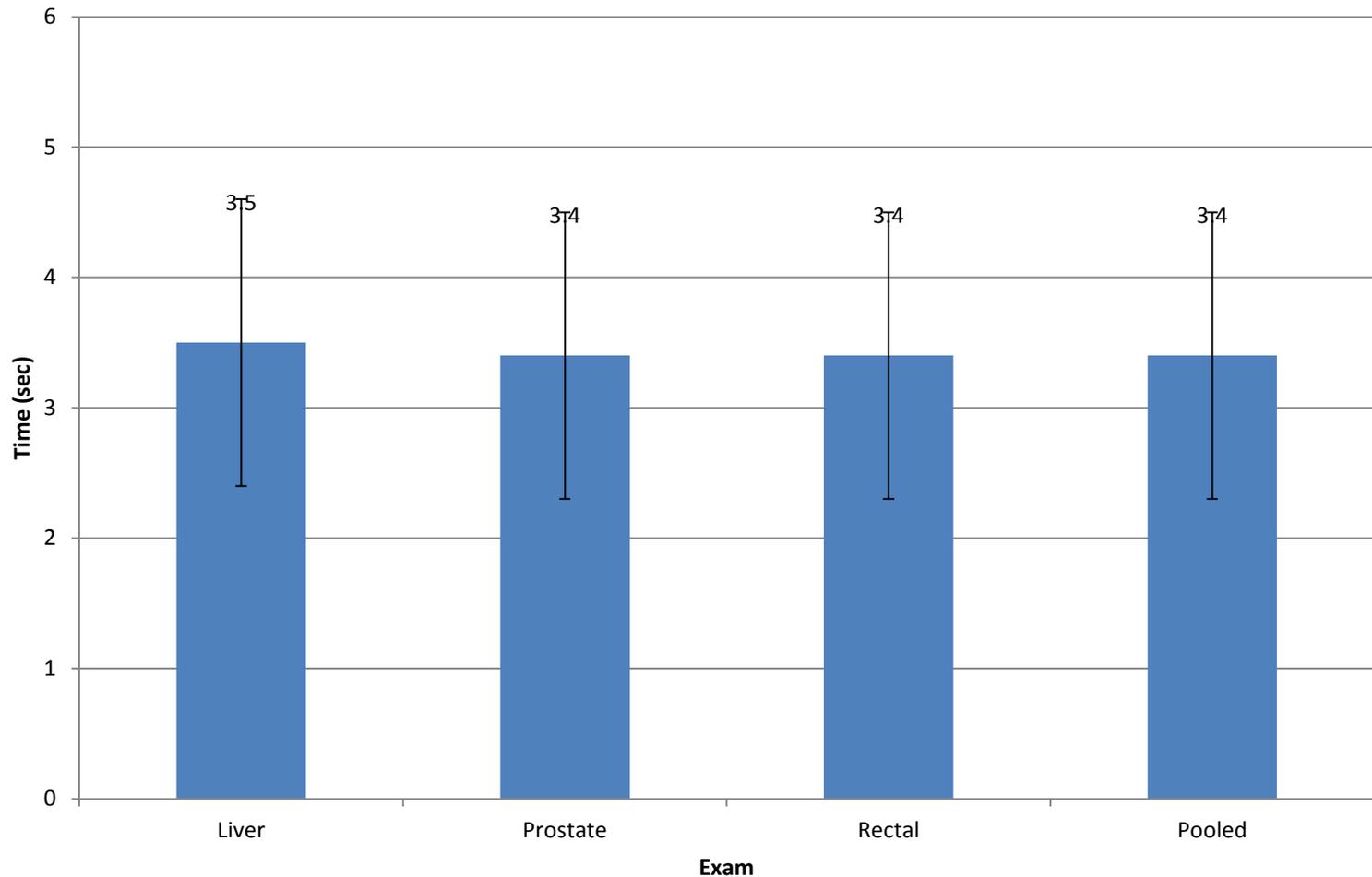
Search results were manually reviewed

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	⦿ Yes ○ No [Reset] Comment:
YES	Exam Number: 14342359 Report Status: Final Ty Exam Number: 14071463 Report Status: Final Ty Exam Number: 13938643 Report Status: Final Ty	⦿ Yes ○ No [Reset] Comment:
YES	Exam Number: 14370779 Report Status: Final Ty	⦿ Yes ○ No [Reset] Comment:
YES	Exam Number: 14545619 Report Status: Final Ty	⦿ Yes ○ No [Reset] Comment:
NO		○ Yes ⦿ No [Reset] Comment:
NO		⦿ Yes ○ No [Reset] Comment: 12/09/08
NO		○ Yes ⦿ No [Reset] Comment:
NO		○ Yes ⦿ No [Reset] Comment:
NO		○ Yes ⦿ No [Reset] Comment:
NO		○ Yes ⦿ No [Reset] Comment:
NO		○ Yes ⦿ No [Reset] Comment:

Cohen's κ was selected as a conservative measure of inter-observer agreement.
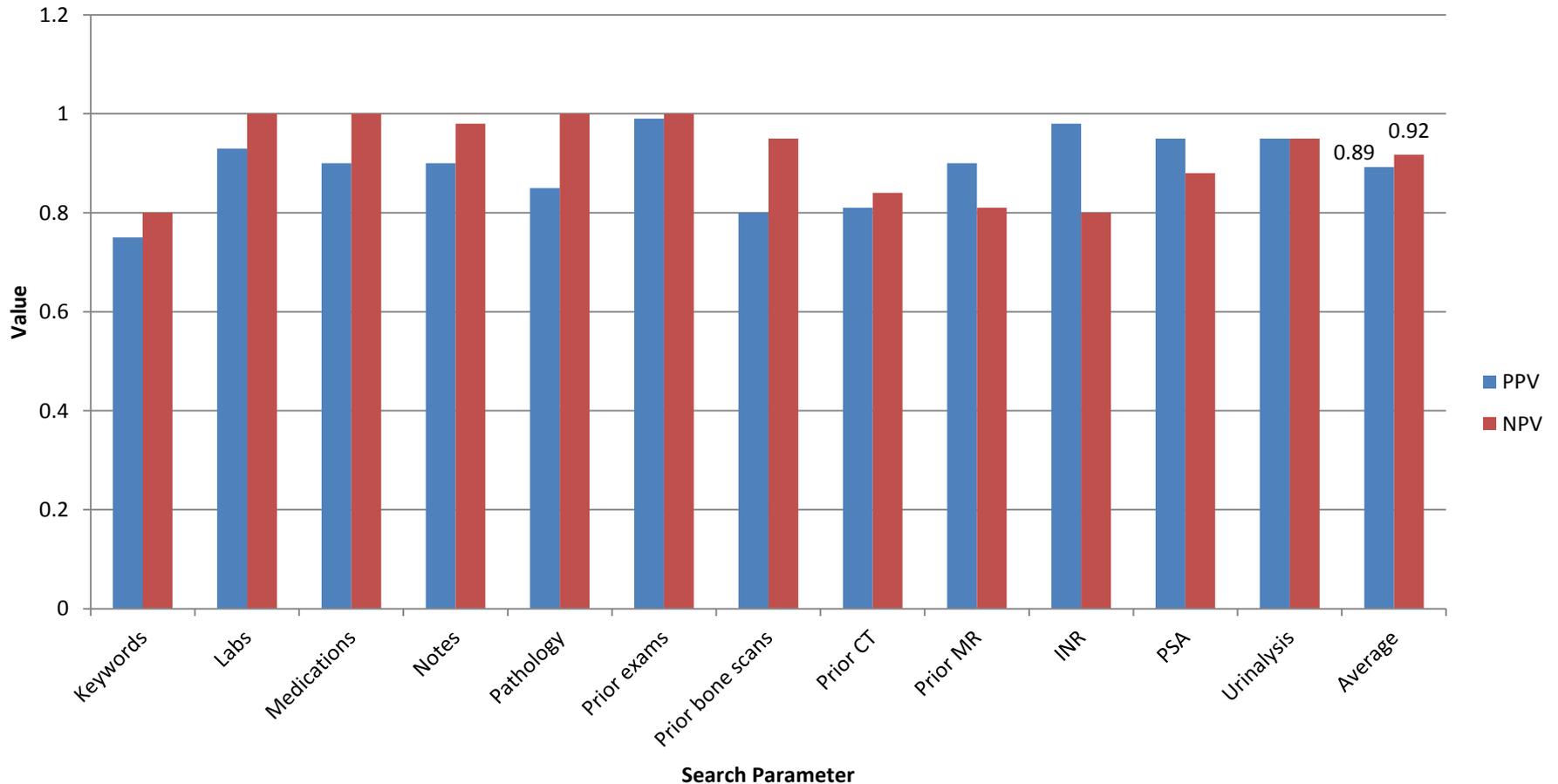- ✓ **κ = 0.90**, indicating a high degree of agreement

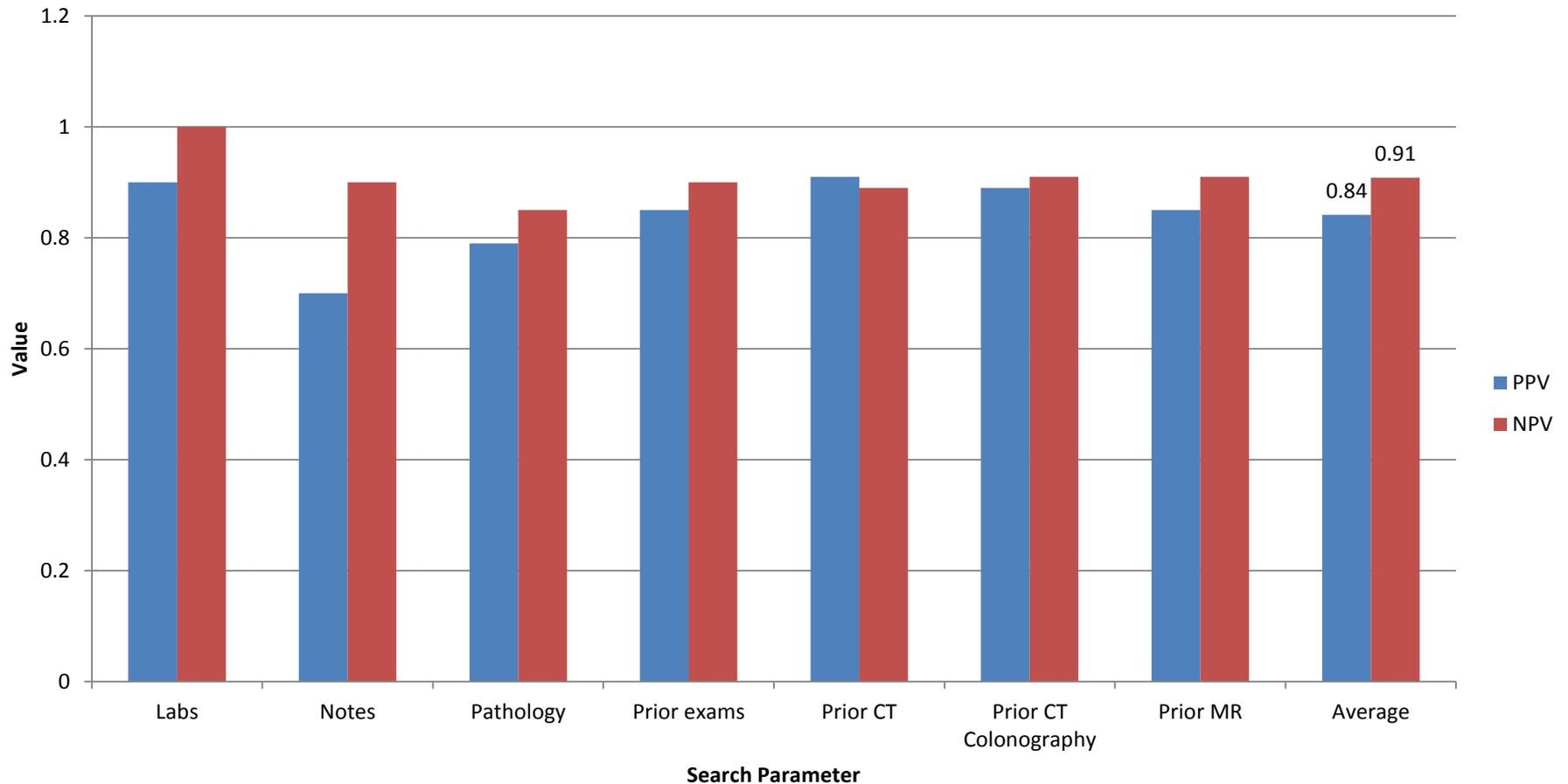# Liver MR searches showed high PPVs, NPVs

Liver MR
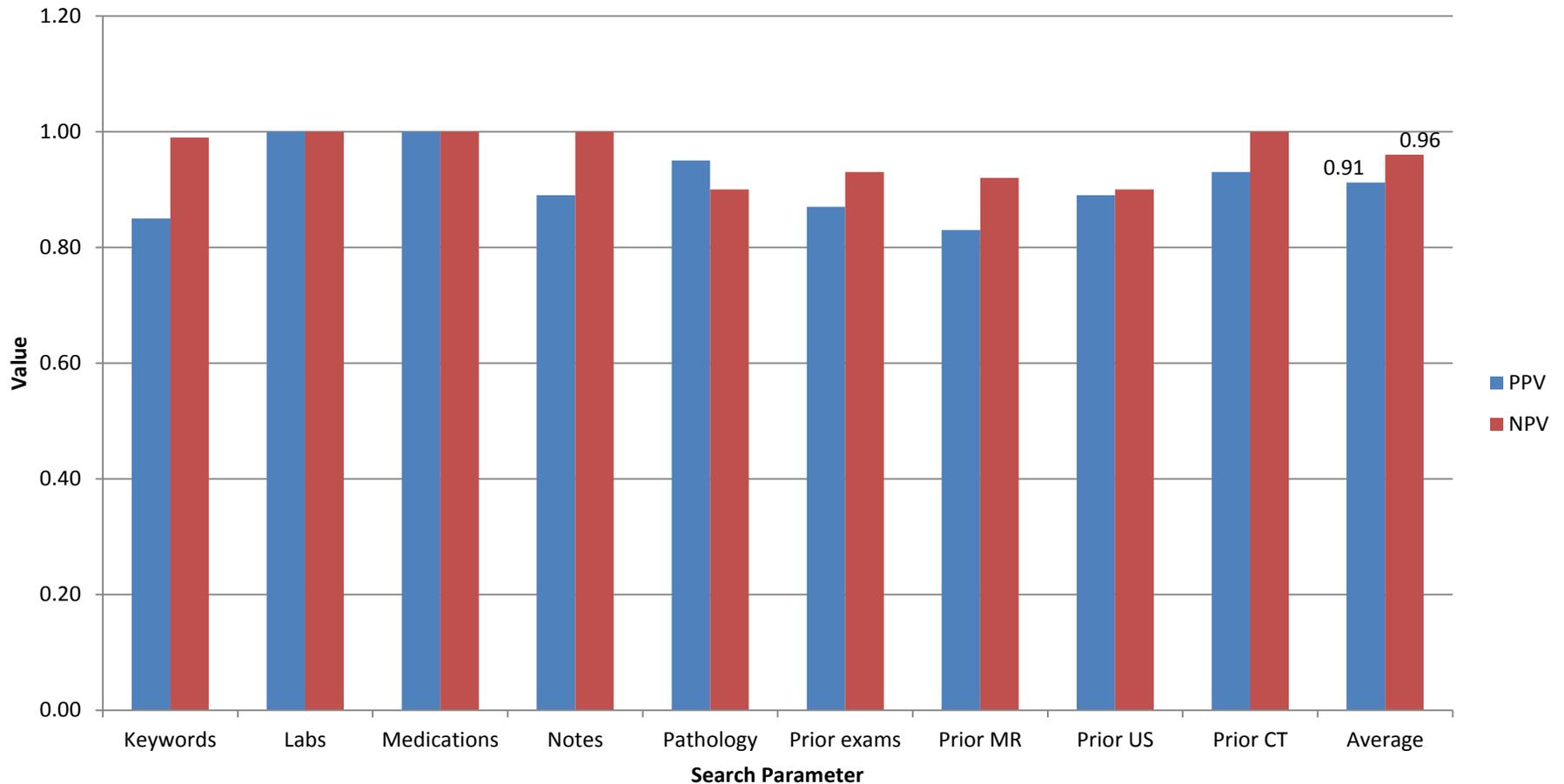
Prostate MR searches showed similar results

Prostate MR

Rectal MR searches showed similar results

Rectal MR

Pooled PPV and NPV was high

$PPV_{\text{all exams, all searches}}$ = **0.86 ± 0.02**

$NPV_{\text{all exams, all searches}}$ = **0.91 ± 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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