Automatic Indexing and Retrieving Context-Specific Evidence to Support Physician Decision Making at the Point of Care

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Outline

1. Background on retrieving medical literature to support evidence based decision making
2. Framework for data-driven indexing and retrieval and evaluation of framework in pediatric asthma
3. Implications of research and general conclusions
Evidence-based decision-making (EBM)

- EBM - “The conscientious, explicit, and judicious use of current best evidence in making medical decisions”
- EBM is widely accepted for various reasons but difficult to implemented
- Retrieving the right evidence at the right place and right time is the overall goal
- But....as the amount of evidence grows it becomes more difficult to find and apply it to a specific patient case
Medical Evidence Retrieval Systems

There are three main categories of medical evidence retrieval systems:

1. Systems that leverage information without any additional processing – e.g. MEDLINE
2. Systems that reformulate queries to manipulate retrieved evidence – System acts as an intermediary between the retrieval and repository
3. Systems with enhanced indexing for medical evidence – e.g. probabilistic models (i.e. word frequencies) or natural language processing
Challenges to Retrieval of Evidence

- Retrieving evidence is difficult for numerous reasons including:
  - Approximately 30,000 new scientific articles are published annually – *content*
  - Lack of standard formatting and indexing schemes to adequately describe medical content in evidence – *context*
  - Existing query mechanisms are ineffective due to the content and context issues described above – *computation*
Automatic Indexing and Retrieving of Context-Specific Evidence

- To overcome the challenges on evidence retrieval we have developed a framework for automated indexing and retrieval of evidence specific to the context of a patient-physician encounter.
- Our framework provides an enhanced indexing mechanism to describe document content and improves upon existing methods for querying repositories.
2. Design of Framework for Evidence Indexing and Retrieval

- Our framework retrieves evidence for the appropriate context of a patient encounter.
- Context is characterized as: treatment, diagnosis and patient related – different literature is needed for different contextual stages.
- Evidence retrieval is centered around nomenclature.
The following issues had to be overcome to properly identify concepts in evidence-based documents and to apply them to index and retrieve relevant documents:

1. A concept may have multiple names with each site having its own ‘local name’
2. Concepts from a patient encounter may not be exactly the same as in the evidence based document
3. Evidence based documents must be examined to identify the match to the current patient case – this includes matching of disease management concepts (i.e. treatment, diagnosis, patient) to suit the physician’s needs
Our framework overcame the issues in three phases:

1. We identify a set of concepts on the basis of their local names and create a mapping between local names and concepts used by the UMLS Metathesaurus – **core index concepts**

2. The set of core index concepts are expanded to include related index concepts (similar, more general, and more specific) using the UMLS Metathesaurus - **expanded index concepts** – which are then identified in evidence-based documents and indexed

3. Mappings between local names and core index concepts are applied using a vector space model (VSM) to retrieve relevant evidence-based documents by executing three queries corresponding to the three categories of core index concepts and combining their results.
2. Design of Framework for Evidence Indexing and Retrieval

- Cochrane library of systematic reviews is the evidence source due to the quality of evidence and standard reporting template it uses.

- To identify evidence for each context the first step was to classify each relevant sys review into an abstract and plain language summary and the individual studies that compose the review.
Three Phases to Framework

Phase 1: Identifying core index concepts
- Local concept names
- Core index concepts
- Evidence-based documents
- Mapping of local names to core index concepts

Phase 2: Indexing evidence-based documents
- Indices of evidence-based documents

Phase 3: Retrieving evidence-based documents
- Context of patient-physician encounter
- Documents relevant for encounter context

Preparation of Evidence

Retrieval
2. Evaluation of the Methodological Framework using a Pediatric Asthma Exacerbations Case Study

Phase 1 - **Identification of Core Index Concepts**

- The local names of treatment- and diagnosis-related concepts were taken from the CAEP (Canadian Association of Emergency Physicians) pediatric asthma CPG which prescribes treatment for different levels of asthma exacerbation severity (mild, moderate and severe), a collaborating physician supplied the patient concepts
Phase 1 - **Identification of Core Index Concepts cont.**

For each local name a corresponding core index concept was identified in the UMLS Metathesaurus and a translation lookup table was created.

<table>
<thead>
<tr>
<th>Treatment-related ($LN_{Tx}$)</th>
<th>Diagnosis-related ($LN_{Dx}$)</th>
<th>Patient-related ($LN_{Pt}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen</td>
<td>Mild asthma</td>
<td>Animal allergy</td>
</tr>
<tr>
<td>Agonists</td>
<td>Moderate asthma</td>
<td>Environmental allergy</td>
</tr>
<tr>
<td>Corticosteroids</td>
<td>Severe asthma</td>
<td>Food allergy</td>
</tr>
<tr>
<td>Anticholinergics</td>
<td></td>
<td>Allergen exposure</td>
</tr>
<tr>
<td>Magnesium sulfate</td>
<td></td>
<td>Inspiratory wheeze</td>
</tr>
<tr>
<td>Methylxanthines</td>
<td></td>
<td>Expiratory wheeze</td>
</tr>
</tbody>
</table>

Local names
Phase 1 - **Identification of Core Index Concepts cont.**

### Core Index Concept Translation lookup tables

**Diagnosis-related ($TL_{Dx}$)**
- **Mild asthma**
  - CUI = C0581124
  - CN = Mild asthma
- **Moderate asthma**
  - CUI = C0581125
  - CN = Moderate asthma
- **Severe asthma**
  - CUI = C0581126
  - CN = Severe asthma

**Treatment-related ($TL_{Tx}$)**
- **Oxygen**
  - CUI = C0030054
  - CN = Oxygen
- **Agonists**
  - CUI = C0243192
  - CN = Agonists
- **Corticosteroids**
  - CUI = C0001617
  - CN = Adrenal Cortex Hormones
- **Anticholinergics**
  - CUI = C0242896
  - CN = Anticholinergic Agents
- **Magnesium sulfate**
  - CUI = C0024480
  - CN = Magnesium Sulfate
- **Methylxanthines**
  - CUI = C0068447
  - CN = Methylxanthine

**Patient-related ($TL_{Pr}$)**
- **Animal allergy**
  - CUI = C0700360
  - CN = Animal dander allergy
- **Environmental allergy**
  - CUI = C0282504
  - CN = Environmental Illness
- **Food allergy**
  - CUI = C0016470
  - CN = Food Allergy
- **Allergen exposure**
  - CUI = C0231874
  - CN = Exposure to allergen
- **Inspiratory wheeze**
  - CUI = C0238614
  - CN = Inspiratory wheezing
- **Expiratory wheeze**
  - CUI = C0231875
  - CN = Expiratory wheezing
3. Results – Phase 2 - Indexing of Evidence-based Documents

- Retrieved systematic reviews for pediatric asthma from the Cochrane Library of Systematic Reviews using a MeSH search
- 56 reviews with Abstract and Plain Language Summary and 423 studies with characteristics of individual studies were retrieved
- Core index concepts (from phase 1) were then expanded with related index concepts (similar, more general, and more specific)
3. Results – **Phase 2 - Indexing of Evidence-based Documents**

**Expanded index concepts for “mild asthma”, “moderate asthma” and “severe asthma”**
3. Phase 3 - Retrieving Evidence-based Documents

- Used the pediatric asthma example and compared automatic retrieval with manual retrieval of an expert physician.
- Expert applied terms were considered the gold standard and we calculated the number of true positive matches.
- TPM was 0.83 for reviews and 0.64 for papers.
- The increased granularity required for patient studies made the match more difficult.
4. Discussion

- Framework provides a means of automatically indexing and retrieving evidence relative to the patient context
- Increased semantic range by using UMLS terms
- Treatment and diagnostic terms taken from CPG, which may enhance their uptake
- Evaluation in pediatric asthma showed that the framework was satisfactory compared to an expert physician for reviews but less satisfactory for individual studies
5. Next Steps

- Incorporate learning mechanisms to track usage of literature
- Link patient data to frameworks for electronic health records
- Continued work on weighting criteria
- Evaluate in other settings – i.e. other diseases, deferring levels of expertise
Thank you

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