Facilitating phenotype transfer using the OMOP common data model in eMERGE

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Facilitating phenotype transfer using a common data model


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eMERGE Network

- Electronic medical records and genomics (eMERGE) Network
  - Funded by NIH’s National Human Genome Research Institute (NHGRI)
- Combine DNA biorepositories with electronic health record systems for large scale, high-throughput genetic research in support of implementing genomic medicine
- 10 sites, 12 years, 136K patients, 64 phenotypes
  - PheKB.org repository
eMERGE Phenotype

• Generally a knowledge-engineered, rule-based definition of a disease or condition.
• Each site has its own local data model, terms
• Aim for high positive predictive value (PPV)
  – Precision
  – Genome-wide association studies require precision
• Primary site creates the definition and generally aims for >90% PPV
  – Secondary site implements and tests PPV
  – Rest of the network implements
Phenotype

• Can take months to create a new phenotype
• Comes with
  – Narrative description
  – Lists of terms (mostly ICD9), drug names
  – Graphical flow chart
  – Sometimes pseudocode
• Generally takes months to then implement it across the network
  – Effort is 2-3 weeks per site
• Much eMERGE research aims to improve phenotype development and sharing
  – Repeatable patterns, tools, specification language
  – Machine learning
Study Design

• NHGRI eMERGE OMOP supplement 2016
• Site converts local database to OMOP
• Select phenotypes (structured data only)
  – Type 2 diabetes mellitus (T2DM)
    • Complex with many data types
  – Attention deficit and hyperactivity disorder (ADHD)
    • Simpler
• Evaluators convert eMERGE phenotype to OMOP (Atlas)
  – Generate Atlas JSON and SQL
Study design

• Share the new phenotype
  – Each site implements and runs it

• Ask each site
  – Time and effort to complete
  – Compare to original eMERGE phenotype
  – Record issues: coding, data, query, DBMS, software stack, organizational, other
Study design

- eMERGE phenotype definition
- OMOP Atlas phenotype
- Local OMOP Atlas implementation
- Local OMOP SQL implementation
- OMOP mappings
- ETL

Original local implementation

Local database

OMOP database

(Evaluators)
Results: Database conversion

• All 10 sites converted database to OMOP
  – 4 to 12 months elapsed time
  – 2 sites report still converting lab and procedure
  – Lab data in local codes, so many did not convert
    • Instead map labs as needed
  – 5 sites installed the stack with Atlas
    • Reasons for not: security, DBMS, effort
Results: phenotyping

• 9 sites did phenotyping exercise
  – 7/9 T2DM and 6/8 ADHD ran phenotype in 1 day
  – Rest took 14 to 144 days elapsed time
    • Other priorities or had to reload data

• Prevalence of condition varied
  – 0.3%-22.4% T2DM
  – 0.1%-12.3% ADHD
  – Age groups, disease cohorts
Results: phenotype

• 5 sites compared OMOP to old phenotype
  – Reasons for not: joined after phenotype was shared, low expected case count, lost original results, change in privacy policy

• Agreement varied 100% to 43%
## Results: T2DM

<table>
<thead>
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<th>Overlap</th>
<th>Original only</th>
<th>OMOP only</th>
<th>Neither</th>
<th>Positive specific agreement</th>
<th>Negative specific agreement</th>
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Results: ADHD

<table>
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<tr>
<th>Overlap</th>
<th>Original only</th>
<th>OMOP only</th>
<th>Neither</th>
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</tr>
</tbody>
</table>
Results

- Implemented a different algorithm
  - Added extra ADHD inclusion diagnosis
  - Added incorrect diabetes exclusion diagnosis
  - Added adult meds because no pediatric patients
  - Added inclusion diagnosis
  - Pulled all diagnoses where should have been problem list

- ADHD exclusion codes too broad
  - Missing exclusion diagnosis
  - Included ICD10 support
  - Not limit to in-person
  - Logic used durations instead of calendar dates

- OMOP Atlas phenotype
  - Daemon configuration
  - How to load JSON
  - Security rules
  - Set schema name and cohort

- Local OMOP SQL implementation

- Local OMOP Atlas implementation

- eMERGE phenotype definition

- OMOP mappings
  - Diabetes ambiguity

- Original local implementation

- Local database
  - Labs not coded (text names only)
  - Meds not coded correctly

- ETL
  - Missing data since merged two EHRs
  - Only moved in-person medications and diagnoses
  - Missing lab tests without visit
  - RxNorm changes over time
    - Observation_period table error
    - Some local diagnoses not moved
    - Used empty strings instead of nulls
    - Modified query to avoid mappings
  - New data added since original query
  - DBMS not support Atlas
  - DBMS uses different power function

- OMOP database
Results: local data

★ Labs not coded (text names only)
★ Meds not coded correctly

*Bold >2%
*Plain 0.2-2%
• Plain <0.2%
Results: local ETL

★ Missing data since merged two EHRs
★ Only moved inpatient diagnoses and meds
★ Missing lab tests without visit
★ RxNorm changes over time
  • Observation_period table error
  • Some local diagnoses not moved
  • Used empty strings instead of nulls
  • Modified query to avoid mappings
Results: original implementation

★ Implemented a different algorithm
★ Used only inpatient diagnoses for inclusion

• Added incorrect exclusion diagnosis
• Added inclusion diagnosis not included in definition
• Added adult meds because no pediatric patients
• Pulled all diagnoses where should have been problem list
• Skipped some encounters
Results: Altas implementation

★ ADHD exclusion codes too broad

• Erroneously missing one ADHD inclusion diagnosis
• Missing exclusion diagnosis
• Optimized to include ICD10 instead of just ICD9
• Logic used durations instead of calendar dates
Results: local Atlas implementation

• Daemon configuration
• How to load JSON
• Security rules
Results: local SQL implementation

- Set schema name and cohort
Results: OMOP mappings

- Diabetes ambiguity
Results: local OMOP database

- New data added since original query
- DBMS not support Atlas
- DBMS uses different power function
Findings

• Sharing of a single computable query uncovered differences among the original implementations despite starting from the same narrative description, codes lists, pseudocode, and flowchart
  – Sharing is hard
Findings

• The eMERGE network was able to convert its databases into the OHDSI OMOP Common Data Model
  – Primary challenge conversion of local laboratory test codes to the LOINC standard
  – ICD* and drugs straightforward
Findings

• Efficiency of sharing phenotypes improved dramatically with most sites able to execute the query within a day

• Is it worth it?
  – Cost of converting database to OMOP (4 months)
  – Savings in implementing phenotype (2 weeks)
  – Breakeven point about 10 to 20 phenotypes
Findings

• Agreement between the OMOP phenotype query and the original eMERGE query varied from perfect to mediocre
  – Problems in the original query
  – Problems in the OMOP query
  – Changes in data
  – Issues in the database
  – (More about data and database than logic)
Limitations

• Only 2 phenotypes
• Half sites could not compare to original
• Only structured data
Conclusion

• Implementing original phenotypes over a network of electronic health record databases had been labor intensive and error prone.
• The potential for a common data model to improve efficiency and consistency.
Thanks

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- **Co-authors**
- **NHGRI**
  
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