Biomedical Informatics

discovery and impact

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

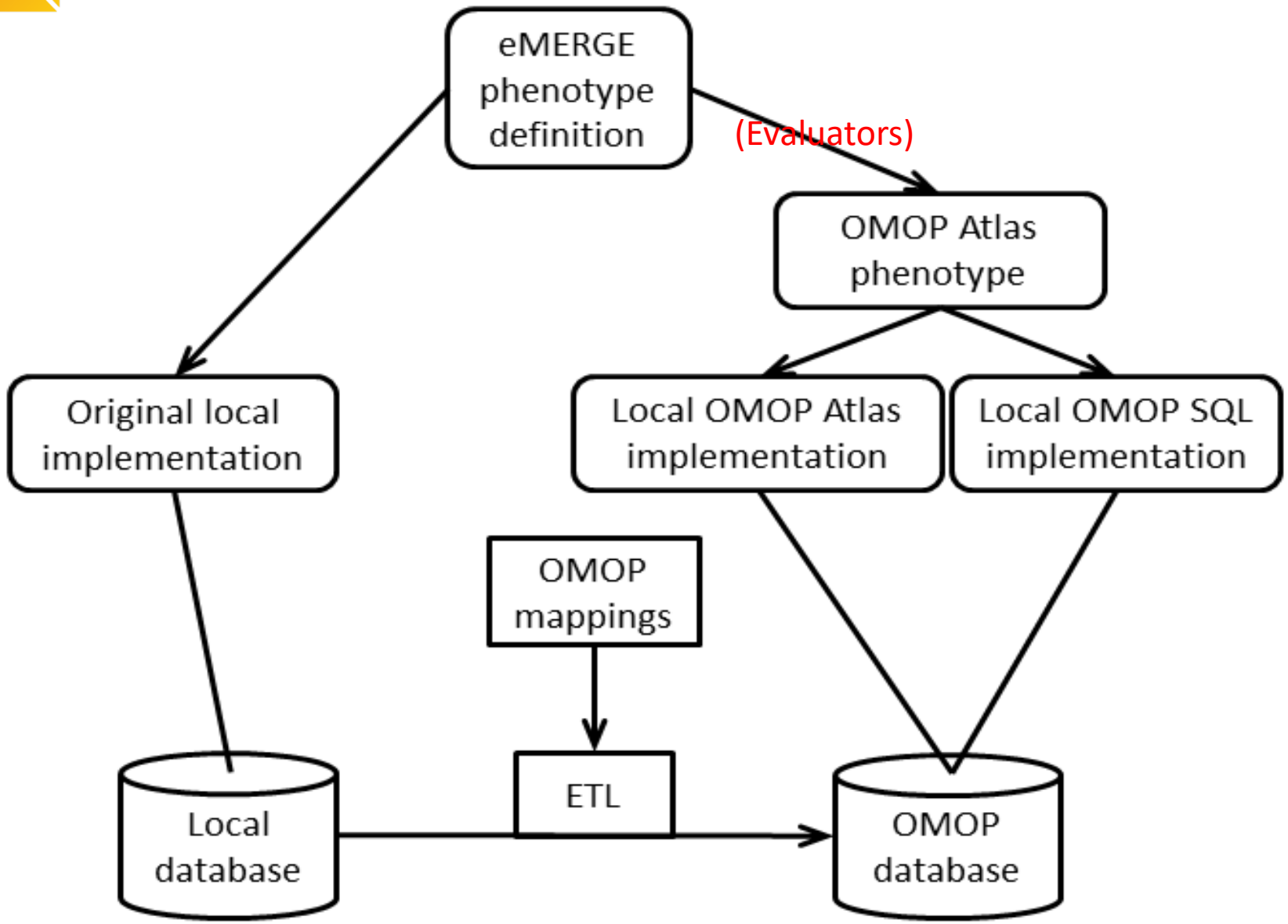
Study Design

- 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



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%

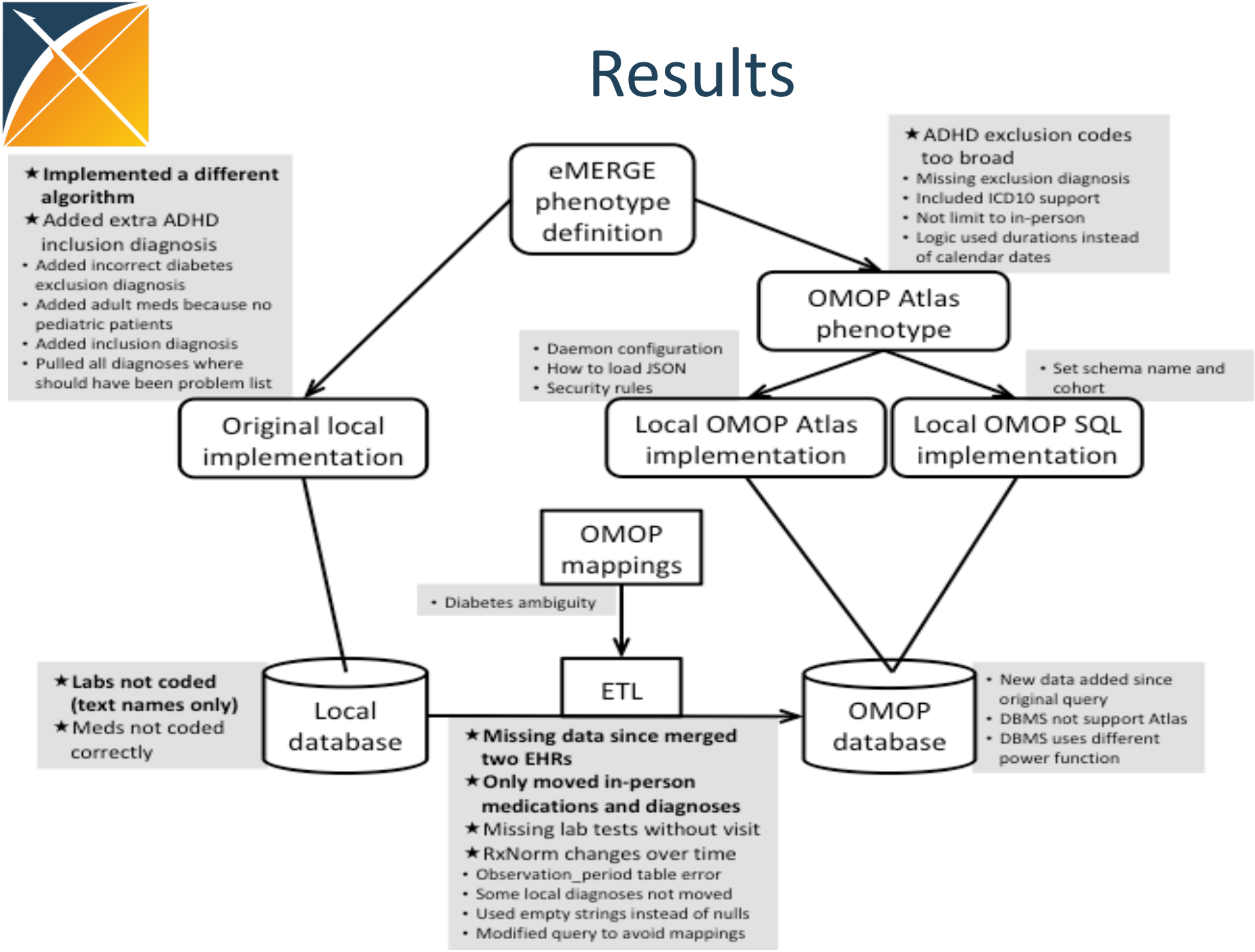
Results: T2DM

Overlap between original and OMOP phenotypes (number)				Positive specific agree-ment	Negative specific agree-ment
Overlap	Original only	OMOP only	Neither		
38	0	4	5465	**0.950**	**1.000**
1179	95	30	4086	**0.950**	**0.985**
242	381	250	4804	**0.434**	**0.938**
735	1165	18	396	**0.554**	**0.401**
3139	819	1588	19143	**0.723**	**0.941**

Results: ADHD

Overlap between original and OMOP phenotypes (number)				Positive specific agree-ment	Negative specific agree-ment
Overlap	Original only	OMOP only	Neither		
7	0	0	5500	**1.000**	**1.000**
23	11	1	5355	**0.793**	**0.999**
1761	507	48	12282	**0.864**	**0.978**
65	15	19	4861	**0.793**	**0.997**

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
eMERGE phenotype definition
★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
Original local implementation
Local OMOP Atlas implementation
Local OMOP SQL implementation
OMOP mappings
• Diabetes ambiguity
★Labs not coded (text names only)
★Meds not coded correctly
Local database
ETL
OMOP database
• New data added since original query
• DBMS not support Atlas
• DBMS uses different power function
★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

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

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