CHORDS: Distributed query of electronic health record systems for surveillance and research

Seth Foldy MD MPH, Denver Public Health/CSPH
and Tessa Crume PhD MSPH CSPH
Objectives

• Learners will be able to:
  – Describe benefits & issues with Electronic Health Record data: access, standards, cost, speed, complexity, privacy, security.
  – Describe how Distributed Query addresses issues
  – Explain how CHORDS’ geographic population focus differs from most distributed query research networks
  – Describe recent/upcoming improvements: coverage, linkage, weighting
  – Access CHORDS for research or surveillance
  – Learn from a researcher
Preventive Medicine Objectives (Clinical Informatics)

- **PC2: Community Health: To monitor, diagnose, and investigate community health problems.**
  - CI2-A: Use informatics and health IT as a tool for prevention on a community level.

- **PC4: Policies and Plans: Develop policies and plans to support individual and community health efforts.**
  - CI4-B: Assess challenges of data management on a patient and population level and discuss the ethical challenges of applying big data to address health problems on an individual and population level (Public Health Essential Service # 6).

- **PC6: Descriptive Epidemiology: Able to characterize the health of a community. & PC7: Analytic Epidemiology: Able to design and conduct an epidemiologic study.**
  - CI6: Apply available data sources to characterize the health of a community (Public Health Essential Service # 2).
Office-based physicians with an electronic health record or electronic medical record (EHR or EMR) system: United States, 2007–2015

Percent of physicians

- Any type of EHR or EMR system
  - 2007: 34.8
  - 2015: 86.9
- Basic system
  - 2007: 11.8
  - 2015: 53.9
- Fully functional system
  - 2007: 3.8
  - 2015: 40.6

CHORDS is a network conceived in 2011 that uses electronic health record (EHR) data to support public health evaluation, monitoring and research efforts.
Privacy & Security

• HIPAA: if too much data about individuals...
  – Consent needed for Research
  – Consent needed for non “authorized public health”
• Risk of theft or misuse of Protected Health Information (PHI)
• **Result**: Studies lack patients who don’t consent (bias – excludes those hard-to-reach or convince)
• **Result**: Difficult to perform research or surveillance across multiple institutions
Privacy & Security: What if we exchanged only a limited data set?

Also called “distributed query”
Privacy & Security
Distributed Data + Aggregated Results

• PopMedNet open source software

• Patient *data remains secure* in each provider’s Virtual Data Warehouse

• Data partners *retain control* over their patients’ data

• *Aggregated* data is shared

• *No trace-back* to individual patients
How is CHORDS Different?

- **Shared** infrastructure for public health and research
- **Low cost per query** compared to population surveys, cohort studies
- Consciously **includes** providers serving populations underrepresented in private tertiary care
- **Integrates** primary care, inpatient, ED and mental health center data
- Continuously growing and reusable
How CHORDS differs from most distributed query networks

‘Typical’ e.g., PCORnet

- Appropriate for Clinical Epi, e.g., “Individual risk factors for hepatitis? How many cases improve with Drug X”?  

Local Focus


Other geo-centric networks include MDPHNET (MA), NYC Primary Care Information Project
Participating Institutions

Data Users:
PH Depts: Metro Denver, Weld, Larimer, CDPHE
Researchers

Technology Partner:
University of Colorado Anschutz Medical Campus

Convener: CHI

Technology Partner:
CORHIO

Data Partners:
Health Care and Mental Health Providers
Complexity:
From Word Salad to Data Model

- EPIC EHR is based on ~12,000 tables
- CHORDS VDW uses 18 tables
CHORDS Data Model | Available Data

- Benefits (e.g., benefit category (e.g., Medicaid, commercial/private))
- Diagnoses (e.g., ICD-9/-10 codes)
- Encounters (e.g., encounter setting, encounter date)
- Laboratory Results (test type, date of test, result –current reporting includes lipids, glycemic, alcohol, hep C, TB, cardiovascular, allergic)
- Patient Demographics (e.g., age, gender, race, ethnicity)
- Patient Residence and Community Factors (e.g., census tract of residence, American Community Survey socioeconomic data)
- Prescribing (e.g., written prescriptions, prescribing physician, quantity, refills)
- Procedures (e.g., ICD-9/-10, CPT, HCPCS codes)
- Social History (e.g., tobacco, alcohol, and/or drug use)
- Vital Signs (e.g., height and weight, diastolic and systolic blood pressure)
- Linkage (e.g., unique identifier used to de-duplicate across data partners)
- Future: Screens for behavioral health, social determinants
Current data partners

**Health Systems**
- Children’s Hospital Colorado
- Denver Health
- Kaiser Permanente Colorado

**Mental Health Systems**
- Mental Health Center of Denver
- Jefferson Center for Mental Health

**Safety Net Providers**
- Clinica Family Health
- Clinica Tepeyac
- Colorado Coalition for the Homeless
- High Plains Community Health Center
- North Colorado Health Alliance
- Salud Family Health Centers
- STRIDE Community Health Center
The Query Process

Data Requester Seeking Information

Includes public health agencies, researchers, others.

CHORDS PopMedNet Query Portal

Authorized requesters access the portal through a web browser and submit their data query.

Each CHORDS Data Partner Site: Health Care and Mental Health Providers

PopMedNet Client and Administrator

Site receives new query. PopMedNet administrator reviews the query and decides whether to execute it.

Firewall

Partner DataMart Administrator

Query is run using a DataMart client software application. A site's DataMart is regularly updated with standardized data from electronic health records.

DataMart (Virtual Data Warehouse)

Portal aggregates results from partners and returns data to requester.

DataMart administrator decides whether to release results back to portal.

DataMart returns results to DataMart administrator.
### Patients in the CHORDS Network by County, 2011-2018

<table>
<thead>
<tr>
<th>County</th>
<th>8-Year CHORDS Total*</th>
<th>5-Year ACS Estimate (2013-2017)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adams</td>
<td>418,325</td>
<td>487,850</td>
</tr>
<tr>
<td>Arapahoe</td>
<td>400,664</td>
<td>626,612</td>
</tr>
<tr>
<td>Boulder</td>
<td>156,738</td>
<td>316,782</td>
</tr>
<tr>
<td>Broomfield</td>
<td>33,626</td>
<td>64,283</td>
</tr>
<tr>
<td>Denver</td>
<td>656,256</td>
<td>678,467</td>
</tr>
<tr>
<td>Douglas</td>
<td>129,523</td>
<td>320,940</td>
</tr>
<tr>
<td>Jefferson</td>
<td>385,449</td>
<td>564,029</td>
</tr>
<tr>
<td>Larimer</td>
<td>85,320</td>
<td>330,976</td>
</tr>
<tr>
<td>Weld</td>
<td>99,344</td>
<td>285,729</td>
</tr>
<tr>
<td>Total</td>
<td>2,365,245</td>
<td>3,675,668</td>
</tr>
</tbody>
</table>

* Prior to Cross-Site Deduplication
CHORDS for Surveillance

• Survey advantages
  – Highly customized
  – Assess behaviors, attitudes
  – Unduplicated sample
  – Established baselines
  – Items designed for data user, validation well understood
  – Access to persons not receiving care
  – Easier to assess and manage missing data

• CHORDS advantages
  – Low cost per query
  – Assess diagnoses, phenotypes, care
  – Deduplication pending
  – Queries of any length
    • Avoids fatigue, response, recall bias
  – Longitudinal
  – Small confidence intervals
  – Granular populations
  – Rapid & changeable
Estimated Prevalence of Children and Youth with Obesity (2012-2014): City and County of Denver

This map displays the percentage of children and youth 2-17 years of age with obesity, by census tract, based upon body mass index (BMI) measurements contributed to the Colorado BMI Monitoring System from multiple health care organizations. BMI was calculated from height and weight and plotted on the Centers for Disease Control and Prevention (CDC) male or female BMI-for-age growth chart to determine a percentile. Obesity was defined as a BMI at the 95th percentile or higher. The percentage with obesity was calculated for each census tract by dividing the number of children and youth with a BMI at the 95th percentile or higher by the total number of valid BMI measurements available in that census tract.

These data are comprised of children and youth 2-17 years of age who reside in the City and County of Denver. The total number of children and youth represented with valid BMI measurements is 79,493, or 60% of the total children and youth population of 133,508, as reported from the 5-year American Community Survey (2010-2014). Census tracts were designated as having insufficient data for display if: 1) the total population was fewer than 50 individuals; or 2) fewer than 50 valid BMI measurements were available; or 3) coverage was less than 20% of the population 2-17 years of age.

Denver County Average: 18%
- Insufficient Data
- Neighborhood Boundary
- County Boundary
- Freeways
- Major Roads

Range: 1% - 26%
CHORDS Adapters & Requests*, Part 1

• BMI Adapter
  – Childhood BMI
  – Adult BMI

• Cardiovascular Disease Adapter
  – Diagnosed Hypertension

• Diabetes Adapter
  – Diagnosed Diabetes (Pre-Diabetes, Type 1, Type 2, All Diabetes)
  – Diabetes Control among Adults with Type 2 Diabetes

• Liver Health Adapter
  – Diagnosed Cirrhosis
  – Hepatitis C RNA Screening

*Ready to use, available through local health departments or CHORDS project mgrs.
CHORDS Adapters & Requests, Part 2

• Mental Health Adapter
  – Diagnosed Depression
  – Diagnosed Depression during Pregnancy

• Substance Use Adapter
  – Diagnosed Cannabis Abuse and Dependence
  – Diagnosed Cannabis Poisoning and Adverse Effects
  – Diagnosed Cannabis Use
  – Diagnosed Opioid Use Disorder

• Tobacco Use Adapter
  – Tobacco Use
Mental Health Data | CHORDS vs BRFSS

CHORDS: one year prevalence of depression dx
BRFSS: lifetime prevalence of depression dx

<table>
<thead>
<tr>
<th>CHORDS 2016</th>
<th>11.3%</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRFSS</td>
<td>20.1% [17.5, 22.6]</td>
</tr>
</tbody>
</table>

- Different prevalence timeframe
- One-time self report & recall vs. recorded medical diagnosis
- CHORDS estimate includes duplicates
CHORDS provides significant data for small population comparisons

PREVALENCE OF DIAGNOSED DEPRESSION AMONG ADULTS 18 YEARS AND OLDER IN DENVER COUNTY BY CENSUS TRACT, 2016

PREVALENCE

- >= 15%
- 10 - <15%
- <10%
- INSUFFICIENT DATA FOR DISPLAY

These CHORDS data reflect diagnoses, and not the prevalence of undiagnosed depression. Thus, it also reflects differences in care-seeking, access to care, and provider impression.

Source: Colorado Health Observation Regional Data Service (CHORDS), 2016
CHORDS for Research: Examples

• Asthma Exacerbation Index
• LARCs and Adolescent Pregnancy
• Spinal Fusion Procedures and Opioids

• Record-level granular data available (e.g. lat/long, all labs over time, etc.) with specific data sharing agreements
Research Use Case: Asthma

Count of asthma related prescriptions, by month

Absolute Eos. vs. % Eos.
Weighting CHORDS Data

- Patients in EHRs may not be representative of the population
- Results are produced as aggregate counts
- Each CHORDS data request creates a new dataset to weight
- CHORDS doesn’t have the resources to weight data for every request – this is something the data user must do
- R & SAS raking programs developed for age, gender and geographic units
- Race/ethnicity requires record level imputation
  - Adding providers, linking records and Fed rules will reduce missing demographic data in near future

Work performed by Liza Reifler (Kaiser) and Emily Bacon (DPH)
Example: Diabetes rates of adults in Denver, 2015 Weighted by age and gender

<table>
<thead>
<tr>
<th></th>
<th>Adjusted Rates (%)</th>
<th>Crude Rates (%)</th>
<th>Absolute Difference (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Population</td>
<td>9.98</td>
<td>10.91</td>
<td>0.93</td>
</tr>
<tr>
<td>Females</td>
<td>9.62</td>
<td>10.58</td>
<td>0.96</td>
</tr>
<tr>
<td>Males</td>
<td>10.34</td>
<td>11.32</td>
<td>0.98</td>
</tr>
<tr>
<td>Adults 18-19</td>
<td>0.75</td>
<td>0.76</td>
<td>0.01</td>
</tr>
<tr>
<td>Adults 20-24</td>
<td>0.97</td>
<td>0.96</td>
<td>0.01</td>
</tr>
<tr>
<td>Adults 25-29</td>
<td>1.16</td>
<td>1.17</td>
<td>0.01</td>
</tr>
<tr>
<td>Adults 30-34</td>
<td>2.04</td>
<td>2.06</td>
<td>0.02</td>
</tr>
</tbody>
</table>
### Patients in the CHORDS Network by Race, 2011-2018

<table>
<thead>
<tr>
<th>Race</th>
<th>8-Year CHORDS Total*</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>1,570,884</td>
</tr>
<tr>
<td><strong>Unknown</strong></td>
<td><strong>468,233</strong></td>
</tr>
<tr>
<td>Black or African American</td>
<td>181,492</td>
</tr>
<tr>
<td>Asian</td>
<td>84,525</td>
</tr>
<tr>
<td>Multiple Race</td>
<td>34,387</td>
</tr>
<tr>
<td>American Indian or Alaska Native</td>
<td>19,475</td>
</tr>
<tr>
<td>Hawaiian or Pacific Islander</td>
<td>6,249</td>
</tr>
</tbody>
</table>

* Prior to Cross-Site Deduplication
Coming Soon! Record Linkage Across Providers for De-duplicated, Longitudinal Data

• Two approaches
  – Using Health Information Exchange (CORHIO) to create a unique Network-wide ID using PHI
    • In testing & QA; available 2019
  – Creating unique Network-wide ID using hashed patient demographic data (Privacy-Preserving Record Linkage, PPRL)
    • Design in process, expected 2020

• Linked records can also improve demographic data (real values rather than imputation)
www.chordsnetwork.org

The Colorado Health Observation Regional Data Service (CHORDS) collects, analyzes, and presents data from participating partners' electronic health record (EHR) to monitor population health, target areas for intervention and conduct research. All data are securely exchanged, removing personally identifiable patient information.

How Does CHORDS Work?
CHORDS uses a secure software application that receives data from partners, including the Health and Human Services, and exchanges it with other healthcare partners. Partners can then use this data to identify trends and patterns in healthcare, allowing them to make more informed decisions about patient care.

Why Become a Data Partner?
Participation in CHORDS can benefit your organization by providing valuable insights into patient care and identifying areas for improvement. The data collected can be used to improve patient outcomes and reduce healthcare costs.

Frequently Asked Questions about Colorado Health Observation Regional Data Service (CHORDS)
1. What is CHORDS?
   CHORDS is a Colorado regional collaboration for sharing health data, including electronic health records (EHRs) and other clinical data, for research and quality improvement purposes.

2. How do people access CHORDS?
   Users access CHORDS through a secure, web-based portal.

3. Is data shared with other organizations?
   Data is shared with other healthcare providers and researchers for the purpose of improving patient care and outcomes.

4. How secure is CHORDS?
   CHORDS uses robust security measures to protect patient data, including encryption and access controls.

5. How can I learn more about CHORDS?
   Visit the CHORDS website or contact the Colorado Health Observation Regional Data Service for more information.

Contents
1. Overview
2. What is CHORDS?
3. Is CHORDS secure?
4. How do people access CHORDS?
5. Is data shared with other organizations?
6. How can I learn more about CHORDS?
CHORDS Maps page URL coming soon!

CHORDS Maps and Data Visualization Hub

The Colorado Health Observation Regional Data Service (CHORDS) is a regional network in Colorado that uses electronic health record data to improve population health neighborhood by neighborhood.

CHORDS generates community-level prevalence estimates for select conditions in Metropolitan Denver, Larimer and Weld counties. This website contains maps of the most recent estimates based on data collected from participating health care and mental health organizations.

Web Maps

PDF Maps

Contact Us

Other data partners are welcome. Please contact us at contactCHORDS@gmail.com to learn more about getting involved.

Can't find what you are looking for? For questions or more information regarding CHORDS, please contact CHORDS Project Manager for Public Health Monitoring, Greg Budney, via email at gregory.budney@dhha.org.

The Colorado Department of Public Health and Environment provides cartographic and web-based mapping services for CHORDS.

Funders

The Colorado Health Foundation

Adult and Child Consortium for Health Outcomes Research and Delivery Science

University of Colorado Anschutz Medical Campus

In-kind contributions from data partners and data users
This interactive map displays the percentage of care-seeking adults with at least one depression or depression-related diagnosis identified by CHORDS. The percentage of adults with depression for each census tract is the total number of adults with at least one ICD-9 or ICD-10 diagnosis code divided by the total number of adults who received care at a participating data partner.

The map examines care-seeking adults age 18 and older. It includes encounters from 863,080 adults, or 31 percent of the total adult population of 2,822,518 in the nine-county area (including Metropolitan Denver, Larimer, and Weld counties).

Census tracts are designated as having insufficient data if: 1) the total population in the census tract was less than 30 adults or 2) fewer than 50 valid care encounters in the census tract were collected; or 3) coverage was less than 10 percent of the adult population.

Download PDF Version of Map

*For a complete list of ICD-9 and/or ICD-10 codes used for depression please review the CHORDS Mental Health Adapter documentation.

Adult Depression Prevalence (2016-2017)

Depression Prevalence among Care-Seeking Adults

- 15.6 - 21.1%
- 13.3 - 15.5%
- 11.4 - 13.2%
- 9.3 - 11.3%
- 4.1 - 9.2%

Insufficient Data

Census Tract 41.06, Denver County, Colorado

Estimated Adult Depression Prevalence*: 13.2%

Number of Care-Seeking Adults with Depression*: 240

Number of Care-Seeking Adults: 1,813

Percent of the Adult Population with at least one healthcare encounter during the observation time period: 29.8%
Percentage of Care-Seeking Adults Diagnosed with Depression (18 years and older)
By Census Tract, Larimer and Weld Counties, Colorado, 2016-2017

This map displays the percentage of care-seeking adults with at least one depression or depression-related diagnosis identified by CHORDS. The percentage of care-seeking adults with depression was calculated by dividing the number of adults with at least one ICD-9 or ICD-10 diagnosis code* residing in a census tract by the total number of adults who received care at a participating data partner.

These data are comprised of care-seeking adults age 18 and older. The total number of adults represented with at least one care encounter during the observation time period is 72,003, or 15% of the total adult population of 473,009, as reported by the latest 5-year American Community Survey. Census tracts are designated as having insufficient data if: 1) the total population in the census tract has fewer than 50 adults; or 2) fewer than 50 valid care encounters in the census tract were collected; or 3) coverage was less than 10% of the adult population.

*For a complete list of ICD-9 and/or ICD-10 codes used for depression please see the CHORDS Mental Health Adapter documentation.
Acknowledgments

• Greg Budney
• Ken Scott
• Tessa Crume
• Emily McCormick-Kraus
• Emily Bacon
• Sara Schmidtt
• Art Davidson
END, INTRO TESSA CRUME
Patients in the CHORDS Network by Age Group, 2011-2018

* Prior to Cross-Site Deduplication