The Health & Environment Linked for Information Exchange (HELIX)-Atlanta Effort:

Air Pollution & Birth Defects Demonstration

Matt Strickland
On behalf of the HELIX-Atlanta Birth Defects Team
MStrickland@cdc.gov
Environmental birth defects tracking

- The ongoing, systematic collection, integration, analysis, and interpretation of data about:
  - Environmental hazards
  - Exposure to environmental hazards
  - Birth defects potentially related to exposure

- The dissemination of information to plan, implement, and evaluate environmental public health action
What is Needed to Implement Environmental Birth Defects Tracking?

- A population-based monitoring system of birth defects with standard methods to ensure
  - A relatively high degree of case ascertainment
  - High quality of diagnostic information
- Ability to geocode records and evaluate completeness and quality of geocoded data
- Access to environmental databases that are relatively complete and of reasonable quality
- Resources and methods for conducting data linkages and data analysis
- Disseminate useful, confidential information
Birth Defects Team Purpose

- Integrate ambient air pollution data with birth defects surveillance on congenital heart defects in 5-County Atlanta during 1994-2002
Epidemiologic Studies

- Ambient air pollution & birth defects
  - Three ecological studies
  - Two case-control studies
    Gilboa et al. (in press)
Demonstration Overview

- Compile retrospective cohort, 1994-2002
  - Heart Defects
  - Births
  - Fetal deaths
- Obtain & characterize ambient pollution measurements
- Group similar cases for analysis
- Validate geocodes
- Integrate Data
Birth Defects Surveillance Data

Metropolitan Atlanta Congenital Defects Program (MACDP), NCBDDD, CDC

- Active surveillance
- Clayton, Cobb, DeKalb, Fulton, Gwinnett
- Presence of serious or major structural defect
- 20 weeks gestation – age six
Selected Cases

- Date of birth/fetal death 1994-2002
- 1+ heart defect
- Exclusions:
  - Chromosomal anomalies
  - Syndromes
### Denominator Data

- **Vital records**
  - Office of Health Information and Policy, GA Division of Public Health
  - Linked with MACDP data at CDC

<table>
<thead>
<tr>
<th>Time-series</th>
<th>Spatio-temporal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of birth/fetal death</td>
<td>Geocodes</td>
</tr>
<tr>
<td></td>
<td>Liveborn/stillborn</td>
</tr>
<tr>
<td></td>
<td>Maternal age</td>
</tr>
<tr>
<td></td>
<td>Previous preterm delivery</td>
</tr>
<tr>
<td></td>
<td>Maternal ethnicity</td>
</tr>
<tr>
<td></td>
<td>Pregnancy complications</td>
</tr>
<tr>
<td></td>
<td>Infant gender</td>
</tr>
<tr>
<td></td>
<td>Pregnancy risk factors</td>
</tr>
</tbody>
</table>
Estimating Exposure Window

- Subtract gestational age (in days) from birth date to get estimate of last menstrual period date (LMP)
- Assumption: Conception occurs 14 days after LMP
- Exposure window: Four week period during heart development (days 16-43 after conception)
Heart Development

Ambient Air Pollution

- NOx + HC
- PM
- O3
- SO2
- PM
- CO + PM

Stationary Sources

Mobile Sources
Approaches for Characterizing Air Pollution Levels

- Four approaches implemented

**Temporal**
- Centrally located, representative monitor
  - Peel et al. (2005) *Epidemiology*, 16, 164.
- Averaging across monitors

**Spatio-temporal**
- Assignment to nearest monitor
- Geostatistical surfacing (ozone & PM$_{2.5}$)
  - Recursive b-spline surfacing, 10 km x 10 km grids
  - Refer to HELIX-Atlanta Respiratory Health Team presentation
Coding & Classification of Birth Defects

MACDP

- 6-digit ICD-9-CM code
- Up to 24 individual defect codes per infant
- 48% of affected infants have 2+ cardiac defect codes

- How do you classify infants with 2+ codes?
Issues in Classification

“How to group a [cardiac] defect has been a major challenge to investigators. Schema that aid the pathologist and surgeon serve the epidemiologist poorly…classification of heart defects by anatomic features may obscure developmental relationships”


“A continuing challenge among birth defects epidemiologists is the classification of congenital heart defects into etiologically meaningful groups”

-Martha Werler (2001) Epidemiology 12: 482-84
Heart Defect Classification

Creating outcome groups for etiologic linkage/analysis is a two-step process

1. Classify the heart
2. Group embryologically similar hearts
Step 1: Classify the infant

- Congenital Heart Surgery Nomenclature & Database Project
  - International effort
  - Standardize nomenclature & reporting
  - Under development
  - As of 3/31/2005: 3043/3791 cases reviewed (80%)

<table>
<thead>
<tr>
<th>DefCode</th>
<th>Verbs</th>
<th>Description</th>
<th>Group</th>
<th>Class Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>745510</td>
<td></td>
<td>Fig. 2° ASD</td>
<td>Anomalous Syst Venous Conn</td>
<td>0010</td>
<td>PFO (gest. age &gt; 36 wks; &gt; 8 wks)</td>
</tr>
<tr>
<td>745620</td>
<td></td>
<td>Unbalanced CAVC defect with small atrial</td>
<td>Aortic Valve Disease</td>
<td>0020</td>
<td>ASD, secundum</td>
</tr>
<tr>
<td>746400</td>
<td></td>
<td>Bicuspid aortic valve, severe aortic valve</td>
<td>AP Window</td>
<td>0030</td>
<td>ASD, sinus venosus</td>
</tr>
<tr>
<td>746500</td>
<td></td>
<td>Mitral valve stenosis</td>
<td>ASD</td>
<td>0040</td>
<td>ASD, coronary sinus</td>
</tr>
<tr>
<td>746601</td>
<td></td>
<td>Coronary Artery Anomalies</td>
<td>AV Canal</td>
<td>0050</td>
<td>ASD, common atrium (single atrium)</td>
</tr>
<tr>
<td>746610</td>
<td></td>
<td>Forms triste HLHS - hypoplastic LV</td>
<td>Cardiomypathy</td>
<td>0060</td>
<td>ASD, NOS</td>
</tr>
<tr>
<td>746620</td>
<td></td>
<td>Conc of the Aorta (all types)</td>
<td>Congenitally Corrected TGA</td>
<td>0070</td>
<td>VSD, Typ I (septum primum)</td>
</tr>
<tr>
<td>747000</td>
<td></td>
<td>Hypoplastic aortic arch</td>
<td>Cor Triatriatum</td>
<td>0075</td>
<td>VSD, Typ II (perimembranous)</td>
</tr>
<tr>
<td>747190</td>
<td></td>
<td>Lacunar Atrial Anomalies</td>
<td>Coronary Artery Anomalies</td>
<td>0080</td>
<td>VSD, Typ IV (muscular)</td>
</tr>
<tr>
<td>747210</td>
<td></td>
<td>Hypoplastic aortic arch</td>
<td>DOLV</td>
<td>0085</td>
<td>VSD, Typ IV (muscular)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DORV</td>
<td>0086</td>
<td>VSD, restrictive / small</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Electrophysiological</td>
<td>0090</td>
<td>VSD, NOS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Heterotaxy</td>
<td>0100</td>
<td>AVC (AVSD), complete CAVSD</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hypoplastic Left Heart Syndrome</td>
<td>0110</td>
<td>AVC (AVSD), internal (transitional)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Interrupted Aortic Arch</td>
<td>0120</td>
<td>AVC (AVSD), partial (ASD, primum)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>LV to Aorta Tunnel</td>
<td>0130</td>
<td>AVC (AVSD), NOS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Miscellaneious, Other</td>
<td>0140</td>
<td>AP window (corp pulmonar window)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mitral Valve Disease</td>
<td>0150</td>
<td>PA origin from asc aorta (hemitruncus)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Partial Anomalous Pulm Venous</td>
<td>0160</td>
<td>Truncus arteriosus</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0180</td>
<td>Partial pulm venous connection</td>
</tr>
</tbody>
</table>

**Non-Heart Defects**

<table>
<thead>
<tr>
<th>DefCode</th>
<th>Verbs</th>
<th>Description</th>
</tr>
</thead>
</table>

**Clinical Diagnosis Only**

- Remove

**Reviewed**

- two ventricle repair

**Heart Complexity**

- Simple
- Association
- Complex
- Normal

**Non-heart Complexity**

- No Other Defects
- Multiple Defects
- Syndrome
- Association
- Unclassified
Step 2: Group infants for analysis

Geocode Validation

- Assess the validity of MACDP geocodes using GIS methods
  - MACDP geocodes outsourced to commercial vendor

- Data sources:
  - USGS orthophoto data
  - Tax parcel data
  - Manual validation (only when necessary)

- Random sample of cases from 2 counties
  - Fulton & Gwinnett
## Geocode Validation

<table>
<thead>
<tr>
<th>Category</th>
<th>Fulton</th>
<th>Gwinnett</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cases</td>
<td>112</td>
<td>81</td>
<td>193</td>
</tr>
<tr>
<td>Available for analysis</td>
<td>83 (74%)</td>
<td>70 (86%)</td>
<td>153 (79%)</td>
</tr>
<tr>
<td>Not available</td>
<td>29 (26%)</td>
<td>11 (14%)</td>
<td>40 (21%)</td>
</tr>
</tbody>
</table>

- 50% of cases not available due to apartment complexes
- Commercial vendor did not geocode 7 of 193 cases
  - We were able to geocode 4 of these 7
Distance Between Rooftop & Vendor Coordinate

Distribution of distances

<table>
<thead>
<tr>
<th>County</th>
<th>50% (median)</th>
<th>90%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fulton</td>
<td>72 m</td>
<td>262 m</td>
</tr>
<tr>
<td>Gwinnett</td>
<td>88 m</td>
<td>330 m</td>
</tr>
</tbody>
</table>
### Distribution of distances

<table>
<thead>
<tr>
<th>County</th>
<th>50% (median)</th>
<th>90%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fulton</td>
<td>9 m</td>
<td>40 m</td>
</tr>
<tr>
<td>Gwinnett</td>
<td>6 m</td>
<td>25 m</td>
</tr>
</tbody>
</table>
Data Integration

- Envisioned integration (once birth records are obtained):
  - Date (for temporal data)
  - Date & geocode (for spatio-temporal data)
Evaluate Utility of Linkage and Sustainability

- Review process and results of project
  - Link cases with vital records
  - Link birth cohort with air quality data
  - Link case addresses with tax parcels & orthophots
- Evaluate process for surveillance purposes
- Identify information technology compatibility issues
- Disseminate results, lessons learned, recommendations
Team Members

**CDC**
- Matt Strickland
- Adolfo Correa
- Csaba Siffel
- Alissa Berzen
- Amanda Sue Niskar
- Katie Kilker

**Other Team Members**
- Bill Mahle (Emory Univ.)
- Mark Reller (Oregon Health & Science University)
- Lorenzo Botto (Univ. of Utah)
- Maury Estes (NASA)
- Solomon Pollard (EPA)
- Nicole Tucker (GA Div. Public Health)

**Acknowledgements:**
CDC: Randolph Daley, Gabriel Rainisch, Andy Dent, Steve Bullard
NASA: Mohammad Al-hamdan, Doug Rickman
Emory University: Paige Tolbert
HELIX-Atlanta Partners
Extra Slides

- (working) guidelines created by the reviewers for classifying heart defects
1) In the setting of double outlet right ventricle (DORV) or single ventricle, we will only use the code for sub-valvar PS (490) even if there is multi-level obstruction including valvar PS.

2) We will use the code for bicuspid aortic valve (555) when only mild AS is present as defined by an echo Doppler gradient of <2.5 m/sec (or cath <20 torr). If a more significant degree of stenosis is present, than the valvar AS code (560) should also be used.

3) For the VSD codes, we would like to be able to distinguish "small, restrictive" (86) in addition to the anatomic sub-type. This code will most typically be used in conjunction with the code for muscular (85) or perimembranous (75).

4) When a patent foramen ovale (PFO) is nearly always present with another lesion, such as tricuspid atresia, it will not be marked as a separate diagnosis. In reality, this code will be used infrequently.

5) When a patent ductus arteriosus (PDA) is present in the setting of critical neonatal lesions such as HLHS, coarctation, or pulmonary atresia, it will not be coded.

6) When the diagnosis of discrete coarctation is made (990), we will not use the code for aortic arch hypoplasia (1000) as this finding is invariably present in varying degrees in this setting. This latter code will be used when it is the only descriptor present in the ROCR.
7) The code discrete subvalvular aortic stenosis (565) should only be used when a
discrete membrane or ridge is present. For example, it should not be used in the
setting of hypertrophic cardiomyopathy with sub-aortic obstruction.

8) When the code for HLHS is used (730), we will not use any of the additional codes for
AS, mitral atresia, or coarctation.

9) In the setting of the DORV variant of mitral stenosis/atresia and hypoplastic LV with
normal aorta, use the appropriate DORV code and the code for Single Ventricle and
mitral atresia (810). If the aorta is atretic (and a Norwood would be the appropriate
operation), use the HLHS code (730) with the DORV code.

10) Tracheal compression that is due to abnormal origin of the innominate
(brachiocephalic) artery should not be coded as a vascular ring.

11) Pulmonary artery stenosis (PPS) should not be coded in infants less than 6 weeks of
age (analogous to the rules used for PDA and PFO).

12) If no congenital heart disease is present, use the 7000 code found in the
miscellaneous section.