

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

Air Pollution & Birth Defects Demonstration

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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**

- Antipenko Ye & Kogut (1993). *Mutation Research*, 289, 145.

- Smrcka & Leznarova (1998). *Acta Chirurgiae Plasticae*, 40, 112.

- Cordier et al. (2004). *Occupational & Environmental Medicine*, 61, 8.

- **Two case-control studies**

- Ritz et al. (2002). *American Journal of Epidemiology*, 155, 17.

- 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), NCBDDDD, 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

Time-series

Date of birth/fetal death

Gestational age

Spatio-temporal

Geocodes

Liveborn/stillborn

Maternal age

Previous preterm delivery

Maternal ethnicity

Pregnancy complications

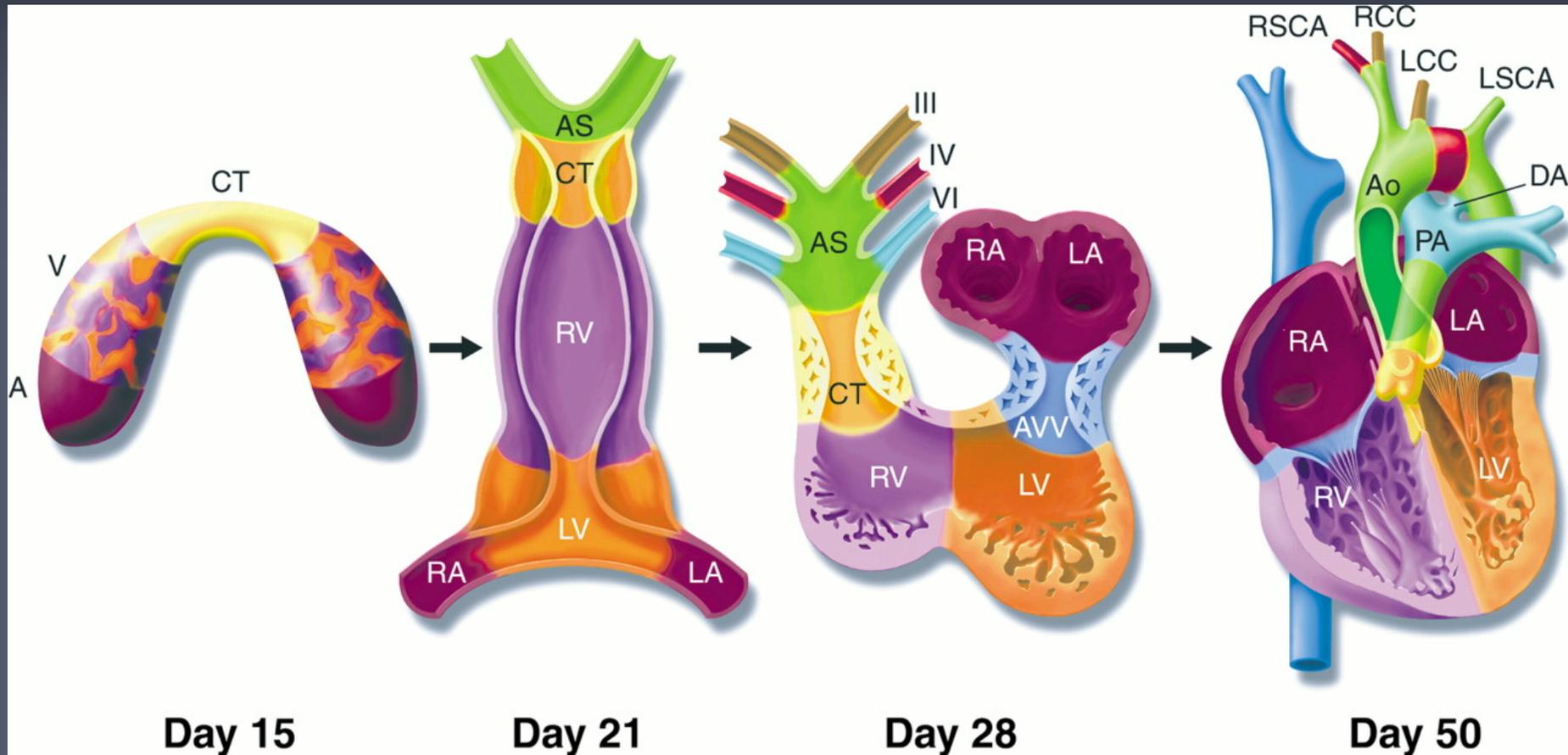
Infant gender

Pregnancy risk factors

Estimating Exposure Window

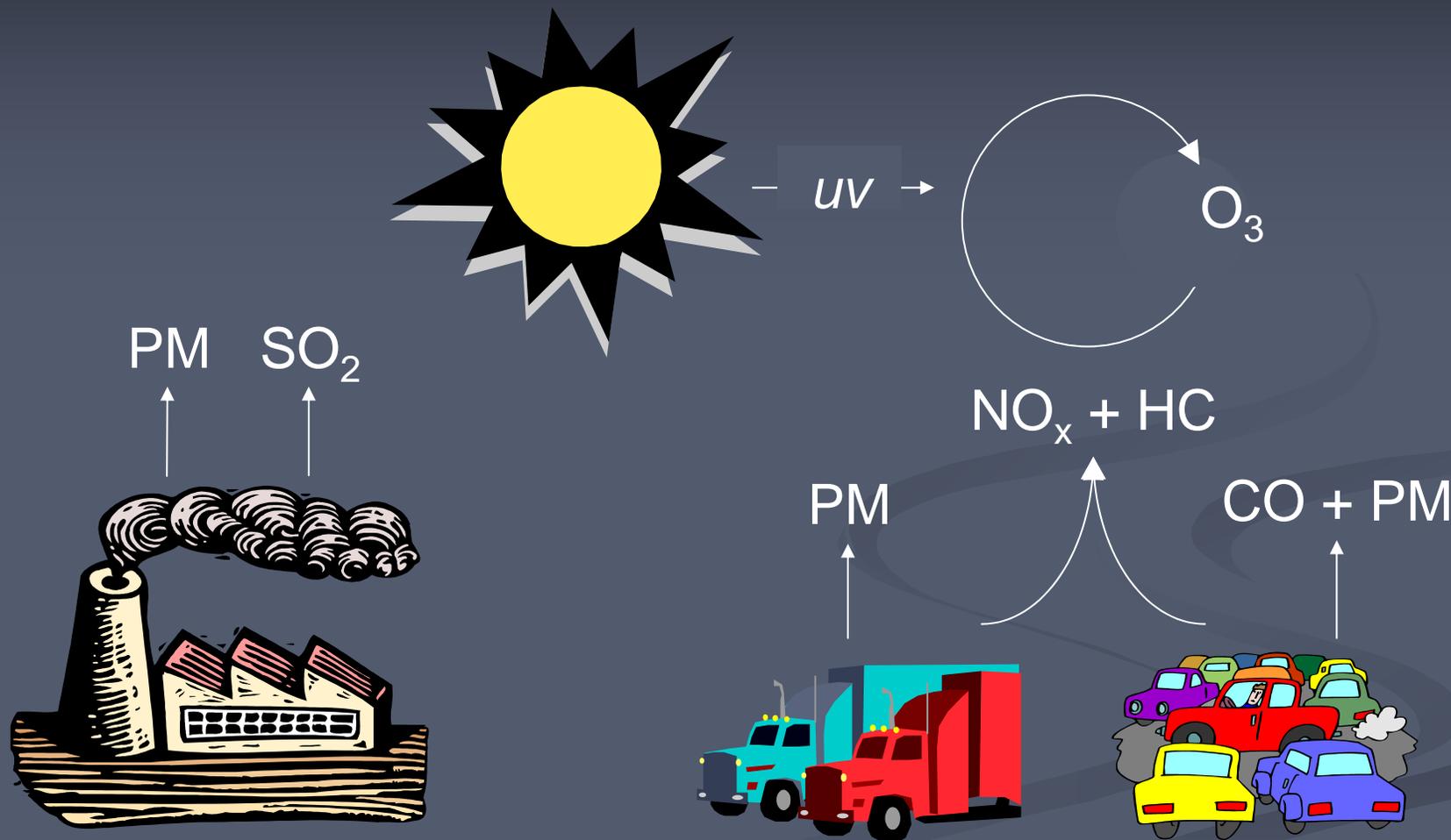
- Subtract gestational age (in days) from birth date to get estimate of last menstrual period date (LMP)
- Assumption: Conception occurs 14 days after LMP
- Exposure window: Four week period during heart development (days 16-43 after conception)

Heart Development



Srivastava, (2001). *Annual Review of Physiology*, 63, 451.

Ambient Air Pollution



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
 - Schwartz (2000) *Epidemiology*, 11, 320.

Spatio-temporal

- Assignment to nearest monitor
 - Similar to Ritz et al. (2000) *Am J Epidemiology*, 155, 17.
- 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”

- Ed Clark (1996) *Sem. in Perinatology* 20: 465-72

“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%)

CDCID ? Assigned To 3 Birth Year Gest Age Birth Wt Sex Outcome

Bill Mahle

Heart Defects

DefCode	Verb	Description
745510	<input checked="" type="checkbox"/>	lrg. 2* ASD
745620	<input checked="" type="checkbox"/>	unbalanced CAVC defect with small atrial
746400	<input checked="" type="checkbox"/>	bicuspid aortic valve; severe aortic valve
746500	<input checked="" type="checkbox"/>	mitral valve stenosis
746881	<input checked="" type="checkbox"/>	forme fruste HLHS - hypoplastic LV
747190	<input checked="" type="checkbox"/>	coarc. of aorta
747210	<input checked="" type="checkbox"/>	hypoplastic aortic arch

Group

Anomalous Syst Venous Conn
Aortic Valve Disease
AP Window
ASD
AV Canal
Cardiomyopathy
Coarc of the Aorta (all types)
Congenitally Corrected TGA
Cor Triatriatum
Coronay Artery Anomalies
DOLV
DORV
Electrophysiologic
Heterotaxia
Hypoplastic Left Heart Syndrome
Interrupted Aortic Arch
LV to Aorta Tunnel
Miscellaneous, Other
Mitral Valve Disease
Partial Anomalous Pulm Venous

Class Code

0010 PFO (gest age: >=36 wks; >=6 wks)
0020 ASD, secundum
0030 ASD, sinus venosus
0040 ASD, coronary sinus
0050 ASD, common atrium (single atrium)
0060 ASD, NOS
0070 VSD, Typ I (subart, supracr, c sep, infund)
0075 VSD, Typ II (perimembranous)
0080 VSD, Typ III (inlet)
0085 VSD, Typ IV (muscular)
0086 VSD, restrictive / small
0090 VSD, NOS
0100 AVC (AVSD), complete CAVSD
0110 AVC (AVSD), intermed (transitional)
0120 AVC (AVSD), partial (ASD, primum)
0130 AVC (AVSD), NOS
0140 AP window (aortopulmonary window)
0150 PA origin from asc aorta (hemitruncus)
0160 Truncus arteriosus
0180 Part anom pulm venous connection

Heart Complexity

Simple

Association

Complex

Normal

Non-heart Complexity

No Other Defects

Multiple Defects

Syndrome

Association

Unclassified

Non-Heart Defects

DefCode	Verb	Description
<input type="text"/>	<input type="checkbox"/>	<input type="text"/>

Classification

Code	Description
0830	Single ventricle, unbal AV canal, right
0020	ASD, secundum

Remove

Clinical Diagnosis Only

Reviewed

Comment

two ventricle repair

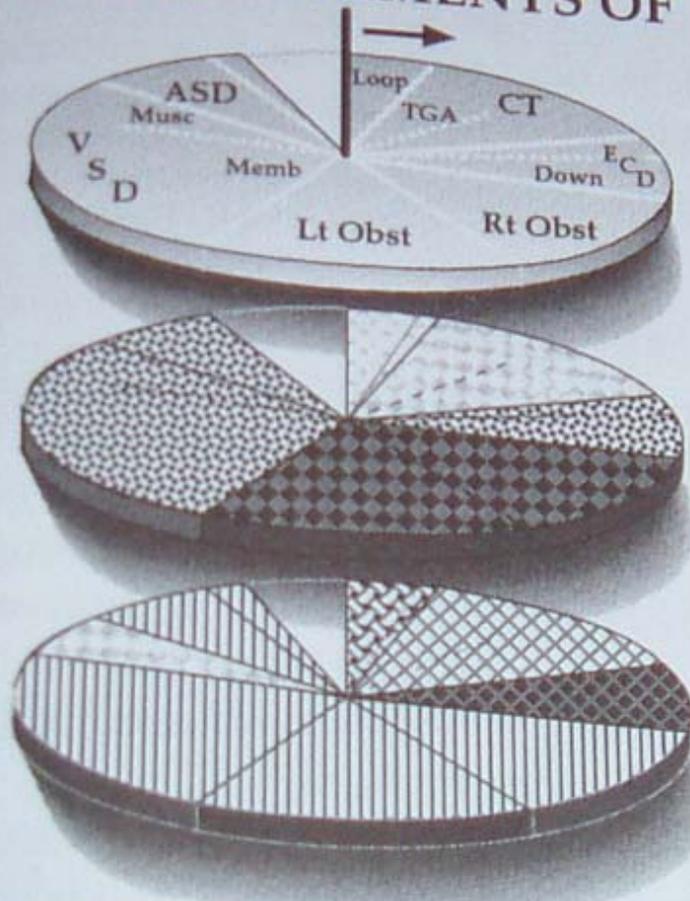
Detailed Description



Step 2: Group infants for analysis

Ferencz et al. (1997) *Epidemiology of Congenital Heart Disease: The Baltimore-Washington Infant Study, 1981-1989.*

RE-ARRANGEMENTS OF



Diagnostic Phenotypes

ANATOMY

- Hierarchy by Presumed Embryonic Timing

ORGANOGENESIS

- Formation of Cardiac Loop
- Conotruncal Septation
- Atrioventricular Septation
- Growth of Heart and Blood Vessels

MECHANISM

- Looping
- Mesenchymal Cell Migration
- Matrix
- Cell Death
- Hemodynamic

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



Geocoded Coordinate

House location

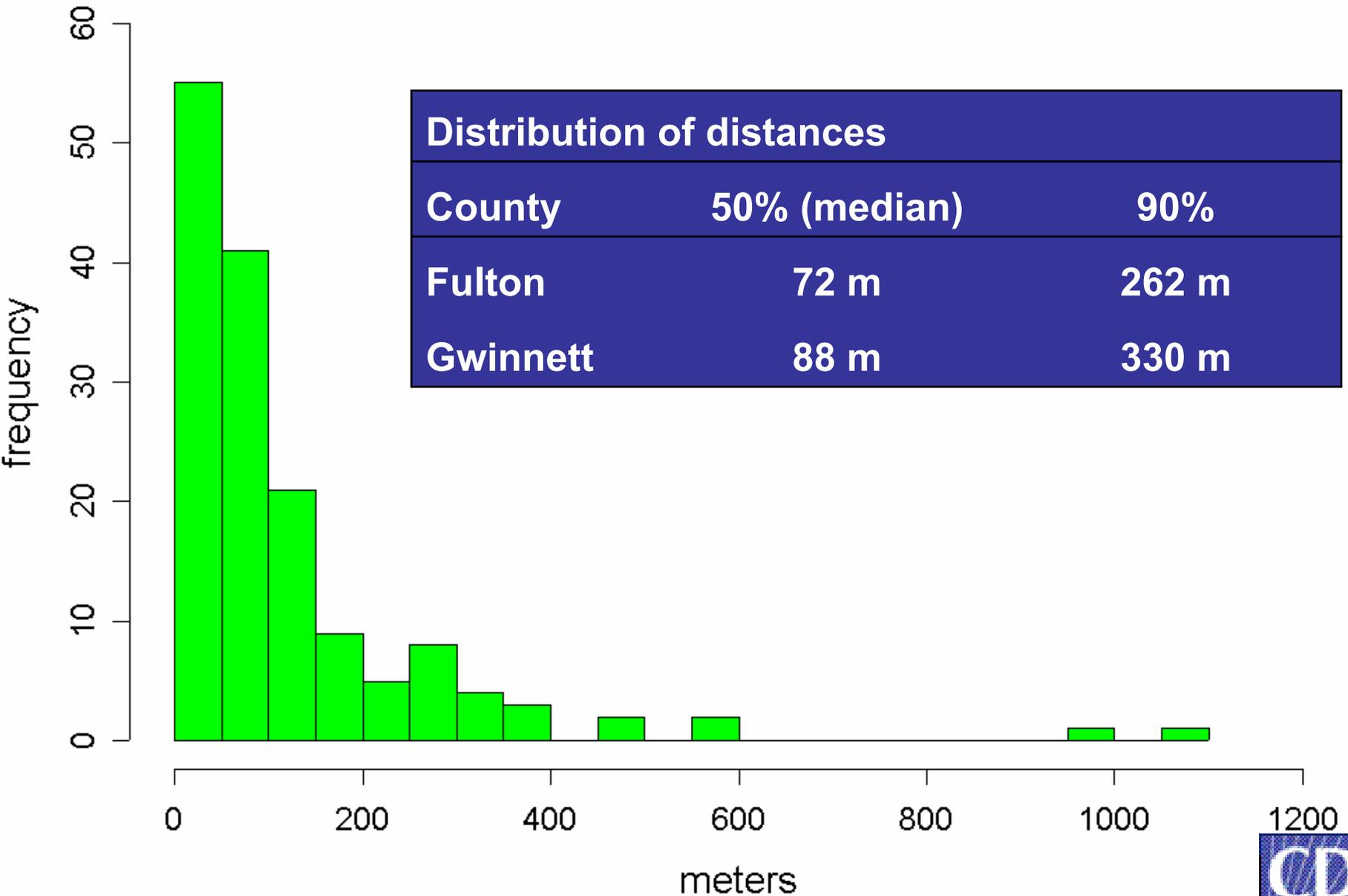


Geocode Validation

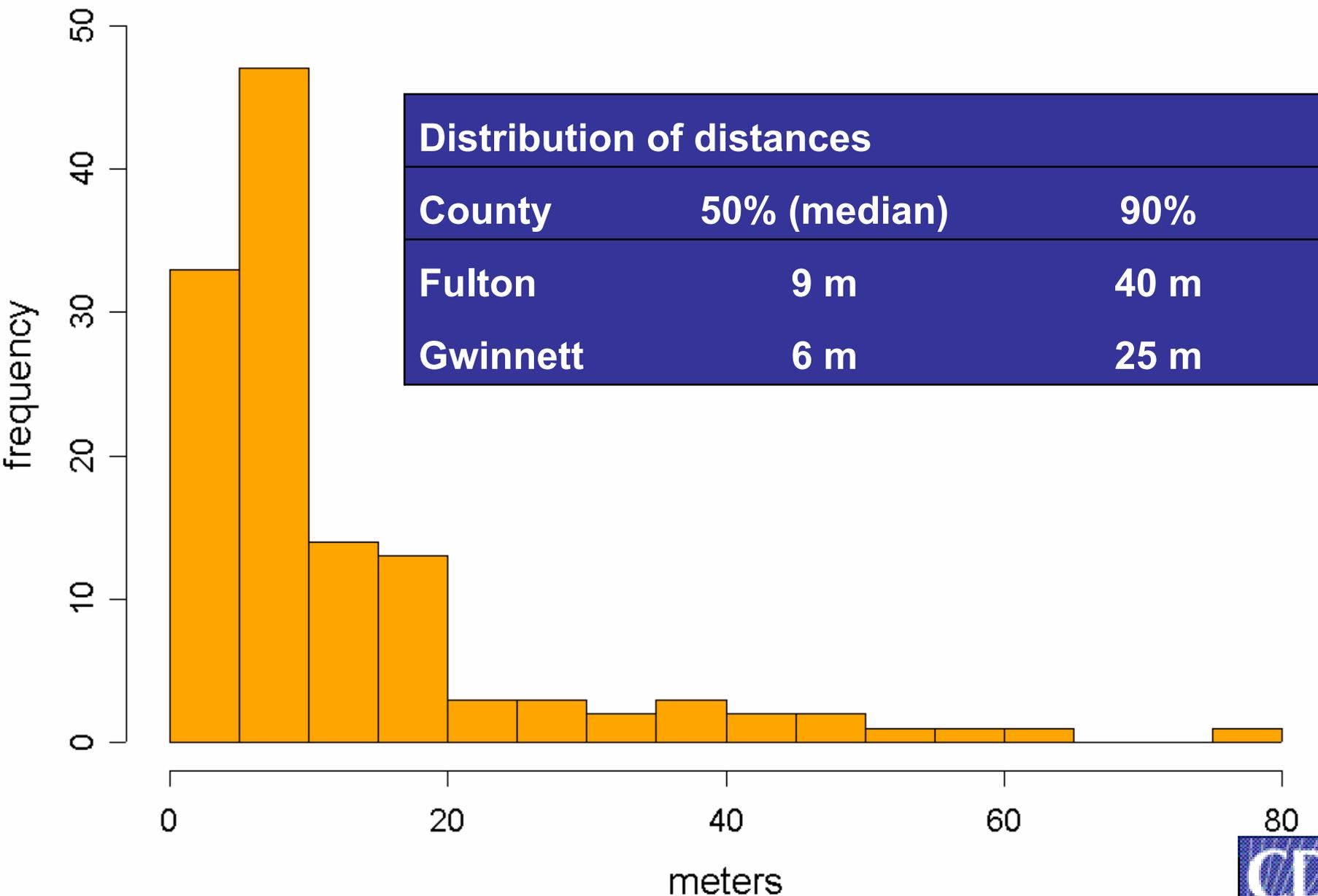
Category	Fulton	Gwinnett	Total
Total cases	112	81	193
Available for analysis	83 (74%)	70 (86%)	153 (79%)
Not available	29 (26%)	11 (14%)	40 (21%)

- 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



Distance Between Rooftop & Parcel Centroid



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)

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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 description 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.