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CONCENTRATIONS OF HEAVY METALS, PCBS, AND OC PESTICIDES IN UMBILICAL CORD BLOOD OR SERUM OF JAMAICAN NEWBORNS

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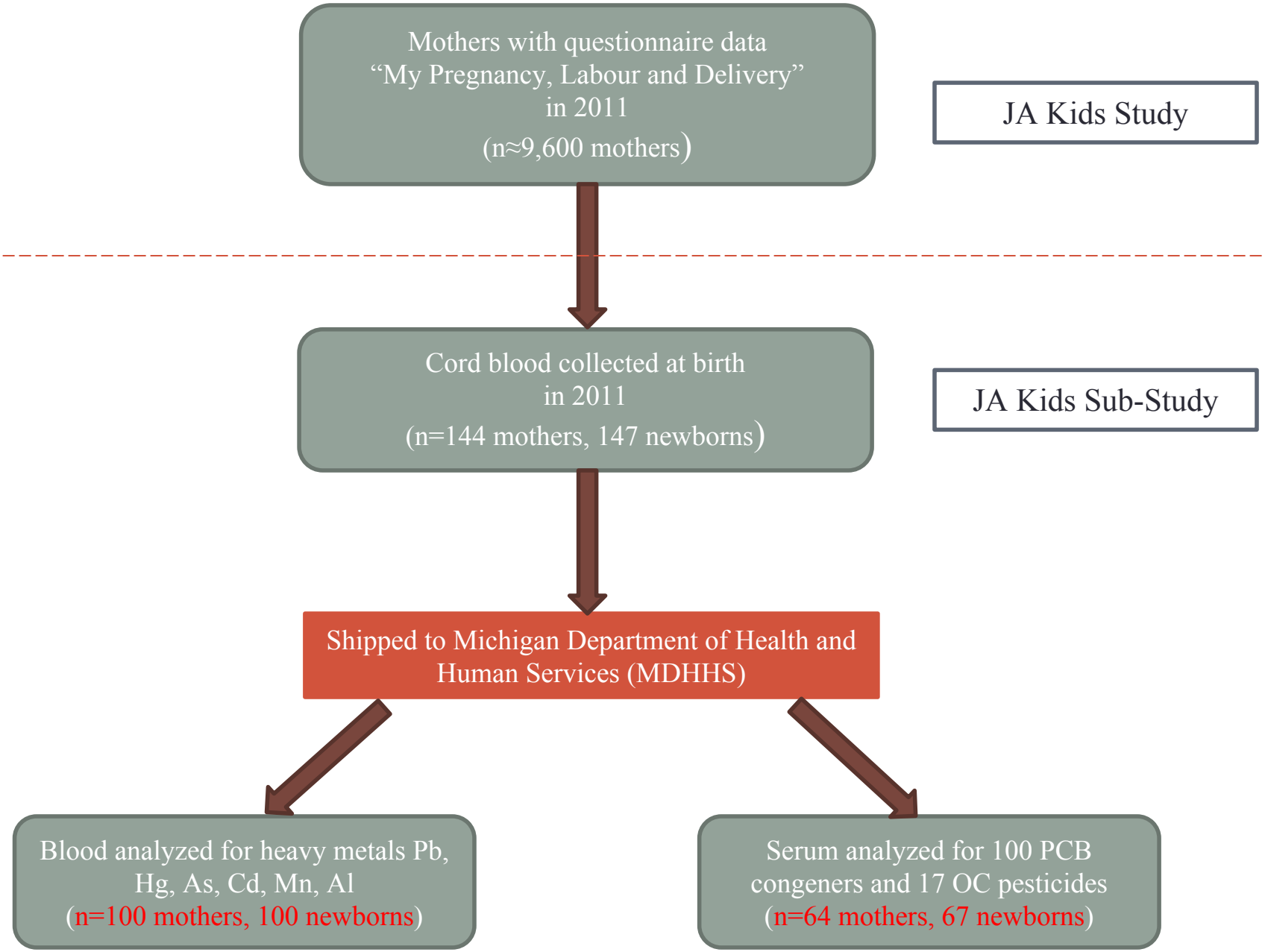
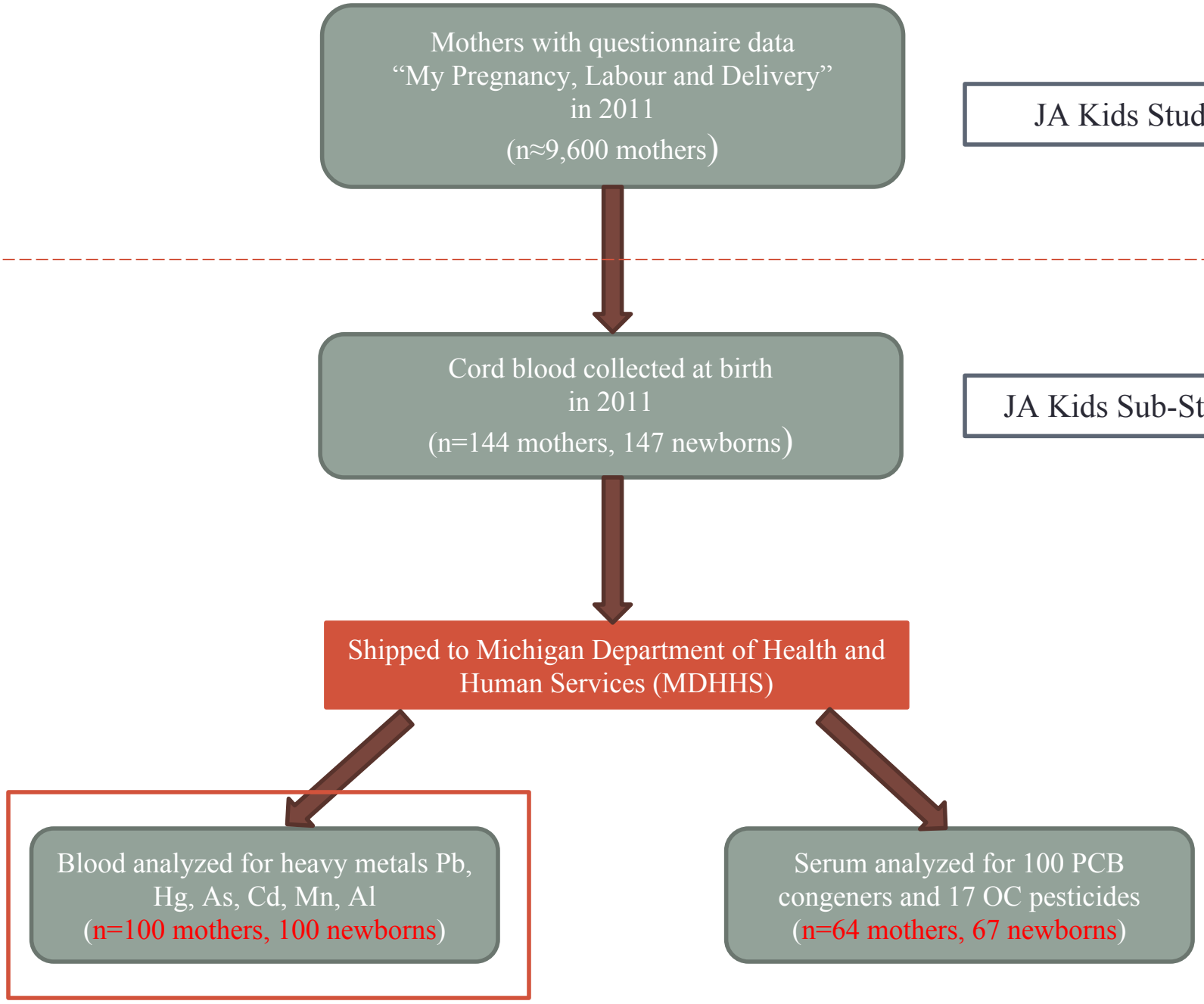
Objectives

- To characterize the concentrations of heavy metals in cord blood and Polychlorinated Biphenyls (PCBs), and Organochlorine (OC) pesticides in cord blood serum of Jamaican newborns.

- To explore possible associations between these concentrations and birth outcomes.


Mothers with questionnaire data
"My Pregnancy, Labour and Delivery"
in 2011
(n≈9,600 mothers)
JA Kids Study
Cord blood collected at birth
in 2011
(n=144 mothers, 147 newborns)
JA Kids Sub-Study
Shipped to Michigan Department of Health and Human Services (MDHHS)
Blood analyzed for heavy metals Pb, Hg, As, Cd, Mn, Al
(n=100 mothers, 100 newborns)
Serum analyzed for 100 PCB congeners and 17 OC pesticides
(n=64 mothers, 67 newborns)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Heavy Metals in Cord Blood

- Limits of detection (LOD)

Heavy Metals	LOD (units)	% Below LOD
Lead (Pb)	0.25 µg/dL	2
Mercury (Hg)	0.25 µg/L	0
Arsenic (As)	0.13 µg/L	78
Cadmium (Cd)	0.13 µg/L	99
Manganese (Mn)	2.50 µg/L	0
Aluminum (Al)	5.0 µg/L	30

- Natural log (Ln) transformation applied to metals whose distributions were skewed (Pb, Hg, Al)

- Geometric mean = Exp [Mean(ln of metal concentration)]

Heavy Metals in Cord Blood

- General Linear Models (GLM) used to investigate heavy metal concentrations by various sociodemographic characteristics

- Correlation coefficients *(r)* used to assess possible association of heavy metal concentrations with birth outcomes
  - Birth weight
  - Crown-heel length
  - Head circumference
  - Apgar 1-minute scores
  - Gestational age

- Multivariable linear regression used to control for potential confounding by maternal education level and socioeconomic status (SES)

Table 1. Individual and household characteristics of the study sample

Variables	Categories	N (%)
Sex of newborn *	Male	45 (45%)
	Female	55 (55%)
Maternal age (years) (at newborn's birth)	Age < 25	21 (21%)
	25 ≤ age < 30	34 (34%)
	Age ≥ 30	45 (45%)
Maternal education (at newborn's birth)	Up to high school	30 (30%)
	Beyond high school	70 (70%)
Previous pregnancies [a]	Yes	57 (60%)
	No	38 (40%)
Assets owned by the family	Cars or other vehicles	51 (51%)

[a] Previous pregnancies is missing for 5 mothers.

Table 2. Distribution of lead, mercury, arsenic, cadmium, manganese, and aluminum concentrations in umbilical cord blood in a sample of n=100 newborns from Jamaica

Variables	N	Mean (SD)		Median	Interquartile range	Percentiles			
		Arithmetic	Geometric			25th	75th	90th	95th
Lead (µg/dL)	100	0.8 (1.3)	0.6 [a] (1.8) [b]	0.6	0.3	0.4	0.8	1.2	1.7
Mercury (µg/L)	100	4.4 (2.4)	3.9 [a] (1.6) [b]	4.0	2.4	2.8	5.2	7.0	7.6
Aluminum (µg/L)	100	10.9 (9.2)	7.7 [a] (2.4) [b]	8.6	13.0	2.5	15.5	22.5	27.5
Manganese (µg/L)	100	43.7 (17.7)	NR [e]	41.0	21.0	41.0	52.0	66.5	80.0
Arsenic (µg/L) [c]	100	1.0 (0.9)	NR [e]	0.6	0.0	0.7	0.7	2.1	2.8
Cadmium (µg/L) [d]	100	0.07 (0.01)	NR [e]	0.07	0.00	0.07	0.07	0.07	0.07

[a] Mean lead, mercury, and aluminum indicates the geometric mean=Exp. [Mean (ln of metal concentration)]
[b] SD of lead, mercury, and aluminum indicates the geometric standard deviation=Exp. [standard deviation of (ln of metal concentration)]
[c] 78 (78%) samples were below the limit of detection for arsenic
[d] 99 (99%) samples were below the limit of detection for cadmium. Also, for ease of understanding, the descriptive statistics for this variable are provided with two decimal places. [e] NR = geometric mean and standard deviation were not reported because ln-transformation was not applied to these variables

Table 3. Descriptive analysis of continuous birth outcome variables stratified by sex of newborns

Birth outcome variables	N			Mean (SD)			Median	Interquartile Range
	Male	Female	Total	Male	Female	Total	Total	Total
Head circumference (cm)	25	30	55	34.0 (1.3)	33.1 (3.7)	33.5 (2.9)	34.0	2.0
Crown-heel length (cm)	22	26	48	46.6 (5.3)	46.8 (4.8)	46.7 (5.0)	48.0	3.5
Birth weight (kg)	44	52	96	3.1 (0.6)	3.0 (0.5)	3.1 (0.6)	3.1	0.6
Apgar 1-minute scores	34	43	77	7.9 (1.7)	8.4 (1.0)	8.2 (1.4)	9.0	1.0
Gestational age (weeks)	35	38	73	38.0 (2.2)	40.5 (7.8)	39.3 (5.9)	39.0	2.0

Table 4a. Univariable association of cord blood metal concentrations with mother's individual and household characteristics as potential confounding variables based on data from n=100 newborns

Variables	Category	N	Lead		Mercury	
			Mean [a] (SD) [b]	*P*	Mean [a] (SD) [b]	*P*
Maternal age (years) (at newborn's birth)	< 30	55	0.6 (2.6)	0.53	3.7 (1.9)	0.22
	≥ 30	45	0.7 (2.4)		4.2 (2.1)	
Maternal education (at newborn's birth)	Up to high school	30	0.6 (3.2)	0.88	3.7 (2.4)	0.35
	Beyond high school	70	0.6 (2.1)		4.1 (1.8)	
Previous pregnancies [c]	Yes	57	0.6 (2.4)	0.51	3.9 (1.9)	0.55
	No	38	0.6 (2.8)		4.1 (2.4)	
Car ownership	No	49	0.6 (2.5)	0.73	3.8 (2.0)	0.30
	Yes	51	0.6 (2.4)		4.1 (2.0)	

[a] Mean lead, mercury, and aluminum indicates the geometric mean = Exp. [Mean (ln of metal concentration)]

[b] SD of lead, mercury, and aluminum indicates the geometric standard deviation = Exp. [standard deviation of (ln of metal concentration)]

[c] Previous pregnancies is missing for 5 mothers

Table 4b. Univariable association of cord blood metal concentrations with mother's individual and household characteristics as potential confounding variables based on data from n=100 newborns

Variables	Category	N	Aluminum		Manganese	
			Mean [a] (SD) [b]	*P*	Mean (SD)	*P*
Maternal age (years) (at newborn's birth)	< 30	55	8.4 (3.3)	0.27	44.0 (24.3)	0.83
	≥ 30	45	7.0 (3.7)		43.2 (26.9)	
Maternal education (at newborn's birth)	**Up to high school**	**30**	**12.2 (4.5)**	**<0.01**	42.8 (32.9)	0.74
	Beyond high school	**70**	**6.4 (2.7)**		44.1 (21.5)	
Previous pregnancies [c]	Yes	57	8.0 (3.2)	0.81	43.0 (24.2)	0.56
	No	38	7.7 (4.1)		45.2 (29.7)	
Car ownership	**No**	**49**	**9.3 (3.4)**	**0.03**	46.0 (25.5)	0.21
	Yes	**51**	**6.4 (3.3)**		41.5 (25.0)	

[a] Mean lead, mercury, and aluminum indicates the geometric mean = Exp. [Mean (ln of metal concentration)]

[b] SD of lead, mercury, and aluminum indicates the geometric standard deviation = Exp. [standard deviation of (ln of metal concentration)]

[c] Previous pregnancies is missing for 5 mothers

Table 5. Correlation coefficients (r) between cord blood metal concentrations and birth outcome variables

Birth outcome variables	N	Lead [a]		Mercury [a]		Aluminum [a]		Manganese	
		Coefficient	*P*	Coefficient	*P*	Coefficient	*P*	Coefficient	*P*
Birth weight (kg)	96	<0.01	0.96	0.13	0.20	0.01	0.89	0.09	0.40
Crown-heel length (cm)	48	0.05	0.71	-0.07	0.64	0.04	0.79	-0.08	0.59
Head circumference (cm)	**55**	**-0.74**	**<0.01**	-0.13	0.35	-0.13	0.69	-0.18	0.20
Apgar 1-minute scores	77	-0.07	0.55	0.01	0.93	-0.10	0.40	0.01	0.93
Gestational age (weeks)	73	0.02	0.88	-0.03	0.78	-0.17	0.14	<0.01	0.96

[a] For lead, mercury, and aluminum, ln-transformed cord blood metal concentrations were used

Table 6a. Multivariable associations between cord blood metal concentrations and birth outcomes after controlling for SES and maternal education in the final multivariable linear regression models for birth outcomes

Birth outcome variables	N	Lead [a]		Mercury [a]	
		Adjusted slope coefficient	*P*	Adjusted slope coefficient	*P*
Birth weight (kg)	96	0.01	0.91	0.16	0.18
Crown-heel length (cm)	48	0.48	0.68	-1.31	0.47
Head circumference (cm)	**55**	**-2.30**	**<0.01**	-0.90	0.34
1-minute Apgar score	77	-0.15	0.56	-0.011[c]	0.98
Gestational age (weeks)	73	0.30	0.77	-0.24	0.87

[a] For lead, mercury, and aluminum ln-transformed cord blood metal concentrations were used

[c] For ease of understanding, the adjusted slope coefficient for 1-minute Apgar score for mercury is provided with three decimal places

Table 6b. Multivariable associations between cord blood metal concentrations and birth outcomes after controlling for SES and maternal education in the final multivariable linear regression models for birth outcomes

Birth outcome variables	N	Aluminum [a]		Manganese [b]	
		Adjusted slope coefficient	*P*	Adjusted slope coefficient	*P*
Birth weight (kg)	96	0.01	0.87	0.002	0.53
Crown-heel length (cm)	48	-0.15	0.87	-0.013	0.79
Head circumference (cm)	55	-0.28	0.59	-0.034	0.19
1-minute Apgar score	77	-0.14	0.50	<0.001[d]	0.92
Gestational age (weeks)	73	-1.46	0.10	-0.006	0.87

[a] For lead, mercury, and aluminum ln-transformed cord blood metal concentrations were used

[b] For ease of understanding, the adjusted slope coefficients for manganese are provided with three decimal

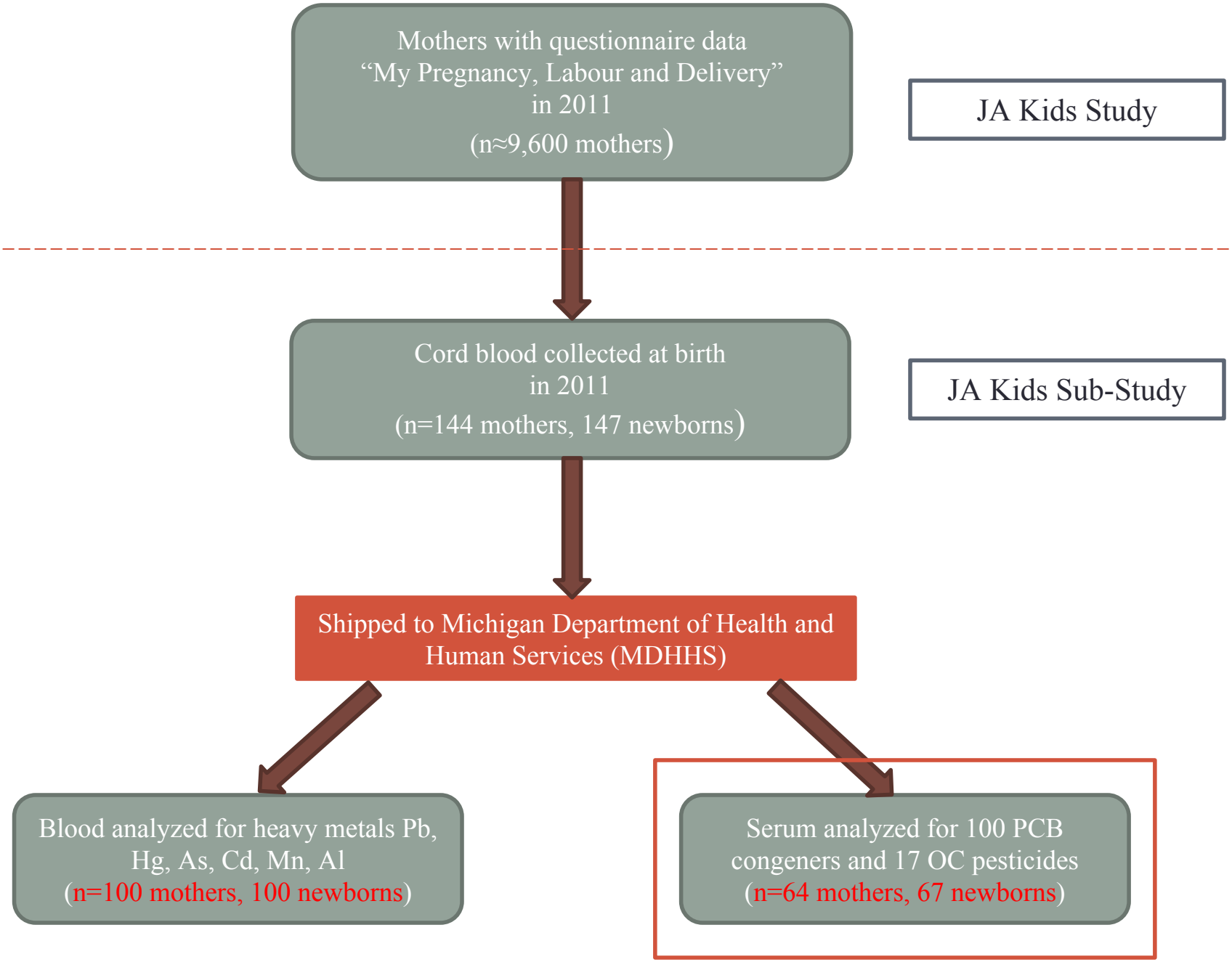
[d] The actual value was 0.00097

Heavy Metals in Cord Blood

- We found significantly higher geometric mean cord blood aluminum concentrations in newborns whose mothers had a lower level of formal education as well as those who were born to families with lower SES.
  - Educating mothers regarding sources of exposure to aluminum could potentially reduce levels of this toxin in Jamaican newborns

- Our results indicate that cord blood lead concentrations in Jamaican newborns are significantly associated with head circumference, even after controlling for maternal education level and SES.

- However, we did not find such associations for concentrations of any of the other five metals with birth outcomes.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PCBs & OC Pesticides in Cord Serum

- Lipid-adjusted analyte concentrations:

$$Lipid\text{-}adjusted\ analyte = \frac{(analyte\ concentration)(sample\ volume)}{sample\ lipid\ weight}$$

- LOD for each analyte:

$$LOD\ analyte = \frac{analyte\ concentration\ in\ lowest\ calibrator}{sample\ volume}$$

PCBs & OC Pesticides in Cord Serum

- Concentrations below LOD were replaced with ½ LOD
- Means and standard deviations (SD) for lipid-adjusted concentrations were assessed
- Concentration of 4,4'-DDE = (4,4'-dichlorodiphenyldichloroethylene (DDE)-Benzene) in cord serum was categorized as a binary exposure variable (below or above LOD)
- Multivariable linear regression analyses to evaluate any potential associations with birth outcomes
  - Birth weight
  - Crown-heel length
  - Head circumference
  - Gestational age

Table 1. Individual and household characteristics of the study participants (N= 67 Newborns from 64 Mothers) from JA Kids study

Variables	Categories	N (%)
Sex of newborn *	Male	27 (40.3)
	Female	40 (59.7)
Maternal age (years) (at newborn's birth)	Age < 25	13 (20.3)
	25 ≤ age < 30	22 (34.4)
	Age ≥ 30	29 (45.3)
Maternal education (at newborn's birth)	Up to high school	25 (39.1)
	Beyond high school	39 (60.9)
Previous pregnancies [a]	Yes	41 (68.3)
	No	19 (31.7)
Assets owned by the family	Cars or other vehicles	33 (51.6)

* Since 3 pregnancies resulted in twins, data are presented for 64 mothers and 67 newborns;

[a] Previous pregnancies status was missing for 4 mothers

Table 2. Descriptive analysis results of birth outcome variables stratified by sex of 67 newborn from JA Kids study

Birth outcome variables	N			Mean (SD)			Median Total	Quartiles*	
	Male	Female	Total	Male	Female	Total		Q1	Q3
Head circumference (cm)	12	19	31	34.0 (1.3)	33.9 (1.4)	34.0 (1.4)	33.7	33.0	34.7
Crown-heel length (cm)	10	18	28	48.7 (1.7)	48.0 (2.7)	48.2 (2.4)	48.5	46.4	49.8
Birth weight (kg)	26	38	64	3.2 (0.6)	2.9 (0.6)	3.0 (0.6)	3.0	2.72	3.40
Gestational age (weeks)	13	14	27	39.5 (0.9)	39.2 (1.4)	39.3 (1.2)	39.4	38.71	40.28

*Q1 = first quartile ; Q3 = third quartile

Table 3a. Lipid adjusted mean concentrations of PCBs in cord blood serum samples of 67 Jamaican newborns from JA Kids study

Measure	N	% below LOD	LOD (ng/mL)	Lipid-adjusted mean (SD) (ng/g-lipid)
PCB congener number				
128, 137, 156, 157, 158, 170, 172, 175, 183, 185, 187, 190, 193, 194, 195, 198, 199, 200, 205	67	100	0.0313	7.05 (1.51)
179,189	66	100	0.0313	7.06 (1.52)
207	60	100	0.0313	7.1 (1.49)
22, 40, 48, 56, 60, 81, 82, 83, 87, 90, 97, 110, 118, 123, 130, 132, 134, 135, 141, 144, 151, 160, 167, 169, 171, 174, 177, 178, 182, 196/203, 201	67	100	0.0625	14.07 (3.01)
64,105, 114, 146	66	100	0.0625	14.09 (3.03)
63	57	100	0.0625	14.01 (3.07)
16, 18, 25, 26, 27, 32, 33, 37, 42, 44, 45, 47, 49, 52, 70, 71, 74, 84, 91, 92, 99, 100, 138/163, 149	67	100	0.125	28.15 (6.03)
17, 31, 101, 136	66	100	0.125	28.18 (6.07)
28	36	100	0.125	27.65 (5.8)
66/95, 77, 126	67	100	0.25	56.29 (12.05)
8	67	100	0.3125	70.36 (15.07)
11	67	100	0.625	140.75 (30.15)
1	61	100	0.625	141.69 (30.72)
3	9	100	0.625	153.62 (38.16)
153	**66**	**98.5**	**0.0625**	**14.25 (3.21)**
180	**67**	**98.5**	**0.0313**	**7.16 (1.71)**
206	**57**	**98.2**	**0.0313**	**7.30 (1.74)**
Total PCB [a]	**67**	**100**	**0.1250**	**28.15 (6.03)**

[a] LOD for total PCB is the algebraic sum of the LODs of the three most common PCB congeners found in biomonitoring samples (PCB153, PCB170, and PCB180);

Table 3b. Lipid adjusted mean concentrations of OC pesticides in cord blood serum samples of 67 Jamaican newborns from JA Kids study

Measure	N	% below LOD	LOD (ng/mL)	Lipid-adjusted mean (SD) (ng/g-lipid)
OC pesticides (*Hexane fraction*)				
HCB [b], Heptachlor, Mirex,	67	100	0.0625	14.07 (3.01)
4,4'-DDE [c]	**67**	**62.7**	**0.1250**	**61.61 (70.78)**
OC pesticides (*Benzene fraction*)				
γ-chlordane, α-chlordane, Oxychlordane, Heptachlor epoxid, trans-nonachlor, cis-nonachlor, 2,4'-DDD [g], 2,4'-DDT [h] and 4,4'-DDT [h]	67	100	0.1250	28.15 (6.03)
γ-HCCH [d], β-HCCH [e], 4,4'-DDE [f], and 4,4'-DDD [g]	67	100	0.2500	56.29 (12.05)
Total-DDE [i]	**67**	**62.7**	**0.1250**	**61.60 (70.76)**

[b] HCB = hexachlorobenzene;
[c] 4,4'-DDE (p,p'-DDE) = 4,4'-dichlorodiphenyldichloroethylene (DDE)-hexane;
[d] γ-HCCH = hexachlorocyclohexane (γ-BHC/lindanee);
[e] β-HCCH = beta-hexachlorocyclohexane (β-BHC);
[f] 4,4'-DDE (p,p'-DDE) = 4,4'-dichlorodiphenyldichloroethylene (DDE)-Benzene;
[g] DDD = dichlorodiphenyldichloroethane;
[h] DDT = ichlorodiphenyltrichloroethane;
[i] LOD for total 4,4'-DDE is the LOD from the lowest fraction.

Table 4. Comparison of mean birth outcomes by detectable status of cord blood serum concentrations of "4,4'-DDE" (below LOD vs. above LOD) using data from JA Kids study

Model	Birth outcomes	Below LOD		Above LOD		*p*
		N	Mean (SD)	N	Mean (SD)	
Univariable	Head circumference (cm)	18	33.78 (1.35)	13	34.38 (1.40)	0.24
	Crown-heel length (cm)	15	48.02 (2.75)	13	48.45 (1.91)	0.64
	Birth weight (kg)	40	2.95 (0.70)	24	3.14 (0.43)	0.18*
	Gestational age (weeks)	17	39.57 (1.08)	10	38.93 (1.34)	0.18
Multivariable (sex-adjusted)	Head circumference (cm)	18	33.83 (1.38)	13	34.43(1.38)	0.24
	Crown-heel length (cm)	15	48.14 (2.42)	13	48.54 (2.42)	0.67
	Birth weight (kg)	40	2.98 (0.60)	24	3.18 (0.60)	0.19
	Gestational age (weeks)	17	39.56 (1.20)	10	38.95 (1.20)	0.23

Unequal variances

Note: Sex-Adjusted standard deviations = square root of mean squared error

Conclusions for the sub-study of PCBs & OC Pesticides in Cord Serum

- Cord serum concentrations for 97 of the 100 PCB congeners and 16 of the 17 OC pesticides were below LOD.

- Our results indicate that cord serum concentrations of PCBs and OC pesticides in Jamaican newborns are similar to or lower than the levels reported for maternal blood in an earlier study from Jamaica and from other studies in the US and Canada.

- We did not find any significant associations between detectable levels of 4,4'-DDE in cord blood serum and select birth outcomes in Jamaican newborns.

Applications & Publications

- Our results could serve as references for the Jamaican population

- Rahbar, M. H., Samms-Vaughan, M., Dickerson, A. S., Hessabi, M., Bressler, J., Coore Desai, C., Shakespeare-Pellington, S., Reece, J.-A., Morgan, R., Loveland, K. A., Grove, M. L., Boerwinkle, E. *Concentration of Lead, Mercury, Cadmium, Aluminum, Arsenic and Manganese in Umbilical Cord Blood of Jamaican Newborns*. Int. J. Environ. Res. Public Health, 2015, 12 (5), 4481-4501, PMC4454921.

- Rahbar, M. H., Samms-Vaughan, M., Hessabi, M., Dickerson, A. S., Lee, M., Bressler, J., Tomechko, S. E., Moreno, E. K., Loveland, K. A., Coore Desai, C., Shakespeare-Pellington, S., Reece, J-A., Morgan, R., Geiger, M. J., O'Keefe, M. E., Grove, M. L., Boerwinkle, E. *Concentrations of Polychlorinated Biphenyls and Organochlorine Pesticides in Umbilical Cord Blood Serum of Newborns in Kingston, Jamaica*. Int. J. Environ. Res. Public Health, 2016, 13 (10).1032. PMC5086771

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UTHealth-Houston Research Team

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- Manouchehr Hessabi, MD, MPH (Research Associate & Data Manager)
- Aisha Dickerson, PhD (Project Coordinator)
- MinJae Lee, PhD (Statistician)
- Mackinsey A. Christian, MS (Project Coordinator)

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- Sydonnie Pellington, MS (Senior Psychologist)
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- Wayne McLaughlin, PhD (Professor and Director of the Genetics Lab)
- Compton Beecher, MS, (Manager, Genetics Lab)
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- The content is solely the responsibility of the authors and does not necessarily represent the official views of the NICHD or the NIH-FIC or the NIEHS or the NCRR or the IDB or the NCATS.

Questions?