UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

NATIONAL CENTER FOR ENIRONMENTAL ASSESSMENT- RTP DIVISION

Research Triangle Park, NC 27711

OFFICE OF RESEARCH AND DEVELOPMENT

May 9, 2014

MEMORANDUM

Subject: Identification and consideration of errors in Lanphear et al. (2005), "Low-Level Environmental Lead Exposure and Children's Intellectual Function: An International Pooled Analysis"

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To: Integrated Science Assessment for Lead Docket (EPA-HQ-ORD-2011-0051)

This memorandum documents errors in a publication cited in the 2013 *Integrated Science Assessment for Lead* (U.S. EPA, 2013, hereafter, 2013 Pb ISA). These errors in Lanphear et al. (2005), "Low-Level Environmental Lead Exposure and Children's Intellectual Function: An International Pooled Analysis," were identified after the completion of the 2013 Pb ISA (see Attachment 1 with Appendix). This memorandum identifies these errors and provisionally considers whether the changes to aspects of Lanphear et al. (2005) that result from correction of the errors materially affect the scientific conclusions made in the 2013 Pb ISA about the effects of Pb exposure on cognitive function or intelligence quotient (IQ).

The 2006 *Air Quality Criteria Document for Lead* (U.S. EPA, 2006, hereafter, 2006 Pb AQCD) and the 2013 Pb ISA in the current review conclude that the concentration-response relationship between blood Pb and cognitive function in young children is nonlinear, meaning that the IQ decrement per µg/dL increase in blood Pb level is larger at lower (versus higher) blood Pb levels. This conclusion is based on the findings from several studies (Tellez-Rojo et al., 2006; Kordas et al., 2006; Lanphear et al., 2005; Canfield et al., 2003; Bellinger and Needleman 2003; Lanphear et al., 2000). Lanphear et al. (2005) conducted a pooled analysis of seven cohorts of children and reported a log-linear relationship between IQ and concurrent blood Pb levels; and linear regression coefficients describing the concentration-response relationship for linear models that were larger for subsets of children with peak blood Pb levels less than 7.5 µg/dL or 10 µg/dL, as compared to subsets with higher peak blood Pb levels. Lanphear et al. (2005) reported these models for concurrent blood Pb, which they state to have the strongest relationship with IQ as measured by R^2.[1] The quantitative modeling of Lanphear et al. (2005), focusing on the shape of the concentration-response relationship, was subsequently corroborated in a separate analysis of the same dataset by Rothenberg and Rothenberg (2005).

[1] The 2006 Pb AQCD and 2013 Pb ISA also evaluated scientific information regarding critical lifestages and time periods of Pb exposure and concluded that decrements in cognitive function were found with several different blood Pb metrics that represent blood Pb during lifestages or time periods from the prenatal period through adolescence (e.g., 2013 Pb ISA, pp. xciv, 4-57, 4-76, 4-248; 4-256, Table 4-14).

Since completion of the 2013 Pb ISA, a publication by Crump et al. (2013) reports findings from a re-analysis of the data for the seven cohorts studied in Lanphear et al. (2005). Crump et al. (2013) reported "some small errors" in the dataset analyzed by Lanphear et al. (2005) and presented results based on analysis of the corrected pooled dataset.[2] Two of these errors were identified after the completion of the final 2013 Pb ISA (see Attachment 2), while EPA had corrected others in the last Pb NAAQS review such that presentations in the 2013 Pb ISA are not affected. [3]

Using a copy of the pooled dataset, we were able to correct the errors and confirm the calculations of Crump et al. (2013) for specific study results that were affected by these errors (see Attachment 1 with Appendix): (1) the non-linear effect estimate for the association between IQ and concurrent blood Pb levels; (2) the linear coefficients for the regressions of concurrent blood Pb on IQ for four groups of children in the dataset with peak blood Pb levels below 7.5 μg/dL, at or above 7.5 μg/dL, below 10 μg/dL, and at or above 10 μg/dL; and (3) the R^2 values for the models with concurrent, early childhood, peak, and lifetime average blood Pb levels. We re-calculated additional statistics that were not reported in Crump et al. (2013) using the corrected dataset (see Attachment 1 with Appendix): (1) absolute IQ decrements over various concurrent blood Pb ranges based on the log-linear model; (2) statistics on the concurrent blood Pb distribution and number of children in the subsets with peak blood Pb levels below 7.5 μg/dL, at or above 7.5 μg/dL, below 10 μg/dL, and at or above 10 μg/dL; and (3) the coefficients for the concurrent blood Pb level-IQ relationship based on the log-linear model, leaving one cohort out at a time.

Although the model coefficients based on the corrected dataset differ slightly from those in Lanphear et al. (2005) (see Attachment 1), the conclusion drawn regarding the finding of a steeper concentration-response relationship at lower blood Pb levels is unaffected. Further, the errors in Lanphear et al. (2005) do not affect the conclusion in the 2013 Pb ISA or the 2006 Pb AQCD, which was based on findings from several studies, that multiple blood Pb metrics including blood Pb level measured concurrent to IQ, were associated with decrements in cognitive function. After correcting and re-analyzing the Lanphear et al. (2005) dataset, Crump et al. (2013) confirmed the primary findings of Lanphear et al. (2005) stating that, "Although we found some small errors and questionable decisions by Lanphear et al. that, taken alone, could cause doubt in their conclusions, our reanalysis tended to support their conclusions." Further sensitivity analyses performed by Crump et al. (2013), including those designed to test whether findings were robust to various interim modeling decisions, do not alter conclusions drawn from the data.

After this provisional consideration of the corrected results for Lanphear et al. (2005) and the publication by Crump et al. (2013), we conclude that the conclusions drawn in the 2013 Pb ISA are not materially affected by these newly identified errors. Accordingly, EPA is not re-opening the air quality criteria for this review to further consider these studies.

[2] Errors in the Lanphear et al. (2005) pooled dataset identified by Crump et al. (2013) also apply to Rothenberg and Rothenberg (2005) who relied on the same original dataset.

[3] We have contacted the primary authors and have received confirmation of the two recently identified errors in the dataset analyzed by Lanphear et al. (2005) (see Attachment 2).

References

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Crump KS, Van Landingham C, Bowers TS, Cahoy D, Chandalia JK. (2013). A statistical reevaluation of the data used in the Lanphear et al. (2005) pooled-analysis that related low levels of blood lead to intellectual deficits in children. Crit Rev Toxicol 43:785-799.

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Rothenberg, SJ; Rothenberg, JC. (2005). Testing the dose-response specification in epidemiology: Public health and policy consequences for lead. Environ Health Perspect 113: 1190-1195.

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U.S. EPA (U.S. Environmental Protection Agency). (2006). Air quality criteria for lead: Volume I of II [EPA Report]. (EPA/600/R-05/144aF). Research Triangle Park, NC.

ATTACHMENT 1: Errors Identified in Lanphear et al. (2005)

ATTACHMENT 2: Emails from R. Hornung (May 1, 2014) and B. Lanphear (February 24, 2014)

ATTACHMENT 1
Errors Identified in Lanphear et al. (2005)

Two aspects to the dataset for the Boston cohort were not accurately represented in the analyses reported in Lanphear et al. 2005.[4] They are as follows (see Attachment 2).

- The IQ data analyzed were for performance IQ rather than full-scale IQ.
- The blood Pb measurements at 6, 12, and 24 months were transformed incorrectly.

Selected Crump et al. (2013) calculations that were confirmed by NCEA with the Boston cohort data correctly represented[5] and statistics from Lanphear et al. (2005) that were re-calculated by EPA are summarized below and presented in detail in Table 1.

a. The log-linear coefficient for concurrent blood Pb changes from -2.70 to -2.65.
b. The model with early childhood blood Pb (rather than concurrent) would have highest R^2, although the values are still very similar (0.6433 as compared to 0.6414 for concurrent metric).
c. The linear coefficient for concurrent blood Pb with IQ for the subgroup of children with peak blood Pb levels <7.5 µg/dL changes from -2.94 to -2.53.
d. The number of children in each of the four linear subset analyses (peak blood Pb below 7.5 µg/dL, at or above 7.5 µg/dL, below 10 µg/dL, and at or above 10 µg/dL) changes as do the descriptive statistics for concurrent blood in these subsets. For example for the subgroup with peak <7.5 µg/dL, the sample size changes from 103 to 118 and the mean blood Pb concentrations from 3.24 to 3.3 µg/dL.

[4] During the 2008 Pb NAAQS review, three typographical errors were identified in Lanphear et al. (2005) and corrections considered. One set of errors pertained to the two numbers associated with the confidence intervals reported at the top of the first column on page 897 (corrections reported in docket number EPA-HQ-OAR-2006-0735-5905). The two numbers were the lower bound on the confidence interval for the linear coefficient for the relationship of IQ with concurrent blood Pb levels for the subgroup of children with peak blood Pb levels ≥ 7.5 µg/dL and the lower bound on the confidence interval for linear coefficient for the relationship of IQ with concurrent blood Pb for the subgroup of children with peak blood Pb ≥ 10 µg/dL. These errors were recognized during development of the 2006 Pb AQCD and corrected in the 2006 Pb AQCD (p. 6-70). The other errors were in the values of the two rightmost columns of Table 4 (corrections reported in docket number EPA-HQ-OAR-2006-0735-5512). These errors were recognized after the final 2006 Pb AQCD was released but prior to the conclusion of the review.

[5] Full-scale IQ was miscoded as verbal IQ. Boston IQ data were corrected by substituting the variable coded as verbal IQ. Boston blood Pb level data for age 6, 12, and 24 months were corrected by subtracting 2 µg/dL from the blood Pb level. Investigators had incorrectly un-transformed data from log form by adding 1 µg/dL to the anti-log of blood Pb instead of subtracting 1.

Table 1. Statistics associated with Lanphear et al. (2005) that were recalculated by EPA

Finding from Lanphear et al. (2005)	Corrected information	Previously reported information	Page number in 2013 Pb ISA where mentioned
Log-linear model coefficient for blood Pb metrics and IQ, adjusted for site, HOME score, birth weight, maternal IQ, and maternal education (Table 4)	Early childhood: -2.21 (-3.38, -1.04) Peak: -2.86 (-4.10, -1.61) Lifetime average: -3.14 (-4.39, -1.88) Concurrent: -2.65 (-3.69, -1.61)[6]	Early childhood: -2.04 (-3.27, -0.81) Peak: -2.85 (-4.10, -1.60) Lifetime average: -3.04 (-4.33, -1.75) Concurrent: -2.70 (-3.74, -1.66)	4-70, 4-254
IQ decrement over different concurrent blood Pb ranges based on the log-linear model	2.4 to 30 µg/dL: 6.7 IQ pts (4.1-9.3) 2.4 to 10 µg/dL: 3.8 IQ pts (2.3-5.3) 10 to 20 µg/dL:1.8 IQ pts (1.1-2.6) 20 to 30 µg/dL: 1.1 IQ pts (0.7-1.5)	2.4-30 µg/dL: 6.9 IQ pts (4.2-9.4) 2.4-10 µg/dL: 3.9 IQ pts (2.4-5.3) 10-20 µg/dL: 1.9 IQ pts (1.2-2.6) 20-30 µg/dL: 1.1 IQ pts (0.7-1.5)	4-70
Linear coefficient, sample size (n) and concurrent blood Pb level measurements (mean, minimum, 5th and 95th percentiles, and maximum) for subset with peak blood Pb levels <7.5 µg/dL	-2.53 (-4.48, -0.58)[6] N=118 (3.3, 0.9, 1.1, 6.7, 7.4 µg/dL)	-2.94 (-5.16, -0.71) N=103 (3.24, 0.9, 1.3, 6.0, 7.4 µg/dL)[7]	Figure 4-2, Table 4-3, Figure 4-15, Table 4-16 pp. 4-70, 4-124, 4-285
Linear coefficient, sample size (n) and concurrent blood Pb measurements (mean, minimum, 5th and 95th percentiles, and maximum) for subset with peak blood Pb levels ≥ 7.5 µg/dL	-0.15 (-0.19, -0.11)[6] N=1215 (13.0, 0.1, 3.7, 34.2, 71.7)	-0.16 (-0.24, -0.08) N=1230 (12.9, 0.1, 3.5, 34.0, 71.7)[7]	Figure 4-15, Table 4-16
Linear coefficient, sample size (n) and concurrent blood Pb measurements (mean, minimum, 5th and 95th percentiles and maximum) for subset with peak blood Pb <10 µg/dL	-0.77 (-1.65, 0.12)[6] N=258 (4.4, 0.1, 1.4, 8.0, 9.8)	-0.80 (-1.74, 0.14) N=244 (4.3, 0.1, 1.4, 8,0, 9.8)[7]	Figure 4-15, Table 4-16 pp. 4-70, 4-124
Linear coefficient, sample size (n) and concurrent blood Pb measurements (mean, minimum, 5th and 95th percentiles, and maximum) for subset with peak blood Pb levels ≥10 µg/dL)	-0.13 (-0.22, -0.04)[6] N=1075 (14.0, 0.1,4.4, 35.5, 71.7)	-0.13 (-0.23, -0.03) N=1089 (13.9, 0.1, 4.3, 35.4, 71.7)[7]	Figure 4-15, Table 4-16
Blood Pb metric with the largest R^2 for the relationship with IQ in the log-linear models	Early childhood R^2: 0.6433 = largest Peak R^2: 0.6401 Lifetime average R^2: 0.6411 Concurrent R^2: 0.6414	Concurrent (no quantitative results presented)	4-256
Sensitivity of concurrent blood Pb-IQ association to omitting one cohort	Slopes ranged from -2.36 to -2.94	Slopes range from -2.31 to -2.94	4-72, 4-76, 4-124, 4-284
Number of children from Boston cohort with peak blood Pb levels < 7.5 µg/dL	Boston = 28	Boston = 13	4-62

[6] Results reported in Crump et al. (2013) and confirmed by NCEA calculations using the corrected dataset (see Appendix). Other results in this column are based only on NCEA calculations using the corrected dataset.

[7] 8/19/2008 and 2/11/2008 emails from Richard Hornung to Jee-Young Kim (docket number EPA-HQ-OAR-2006-0735-5814).

Appendix to Attachment 1

Computer Code for EPA Recalculations

```
libname pooled '\\AA.AD.EPA.GOV\ORD\RTP\USERS\K-Q\mpatel04\Net
MyDocuments\Lead\Pooled Dataset';

proc format;
value lgender 0='Male'
              1='Female';
value lrace 0='Non-white'
            1='White';
value YN 0='No'
         1='Yes';

data pooled.BostonPb; set pooled.tablespaper;
/*tablespaper is the uncorrected SAS dataset */
if site NE "Boston" then delete;
pbch6m2 = pbch6m-2;
pbch1y2 = pbch1y-2;
pbch2y2 = pbch2y-2;
rename pbch6m2 = pbch3 pbch1y2 = pbch1 pbch2y2 = pbch2 pbch4y = pbch4;
/*This program was first run without subtracting 2 from the blood Pb metrics.
The purpose of this first run on the original variables was to check whether
the calculations in this program could replicate the early childhood and
lifetime average blood Pb levels reported in the Lanphear paper*/
keep ID pbch6m2 pbch1y2 pbch2y2 pbch4y lead peaklead meanlead6m_concurrent
meanlead6m_24m pbch6m pbch1y pbch2y peakl10 peakl75;
run;

proc sort; by ID;
run;

data pooled.BostonPb2; set pooled.BostonPb;

array pbarray[4] pbch1-pbch4;
do I = 1 to 4;
pbch = pbarray[I];
if pbch NE . then output;
end;
keep ID pbch;
run;

proc sort; by ID;
run;

proc means noprint;
var pbch;
by ID;
output out = pooled.bostonPb3;
run;

data pooled.Bostonmax; set pooled.bostonPb3;
if _stat_ = "MAX";
peak2 = pbch;
drop _type_ _freq_ _stat_ pbch;
```

```
run;

data pooled.Bostonavg; set pooled.bostonPb3;
if _stat_ = "MEAN";
life = pbch;
drop _type_ _freq_ _stat_ pbch;
run;

data pooled.Bostonearly; set pooled.BostonPb;
array pbarray[3] pbch1-pbch3;
do M = 1 to 3;
pbch = pbarray[M];
if pbch NE . then output;
end;
keep ID pbch;
run;

proc sort; by ID; run;

proc means noprint;
var pbch;
by ID;
output out = pooled.Bostonpb4;
run;

data pooled.bostonearly2; set pooled.Bostonpb4;
if _stat_ = "MEAN";
early = pbch;
drop _type_ _freq_ _stat_ pbch;
run;

data pooled.bostonnewPb;
merge pooled.Bostonmax pooled.BostonPb pooled.Bostonearly2 pooled.BostonPb
pooled.Bostonavg;
by ID;
if peak2 LT 10 then peakl10_2 = 1;
if peak2 GE 10 then peakl10_2 = 0;
if peak2 LT 7.5 then peakl75_2 = 1;
if peak2 GE 7.5 then peakl75_2 = 0;
keep ID peaklead peak2 peakl10 peakl10_2 peakl75 peakl75_2 early life;
run;

data pooled.Lanphearcorrected;
merge pooled.bostonnewPb (keep = ID peak2 early life peakl10_2 peakl75_2)
pooled.tablespaper;
by ID;

if Site = "Boston" then iq = wiscr10v;
if Site = "Boston" then meanlead6m_24m = early;
if Site = "Boston" then meanlead6m_concurrent = life;
if Site = "Boston" then peaklead = peak2;

if Site = "Boston" then if peakl10 = 1 then if peakl10_2 = 1 then peakl10 =
1;
if Site = "Boston" then if peakl10 = 0 then if peakl10_2 = 0 then peakl10 =
0;
```

```
if Site = "Boston" then if peakl10 = 0 then if peakl10_2 = 1 then peakl10 =
1;

if Site = "Boston" then if peakl75 = 1 then if peakl75_2 = 1 then peakl75 =
1;
if Site = "Boston" then if peakl75 = 0 then if peakl75_2 = 0 then peakl75 =
0;
if Site = "Boston" then if peakl75 = 0 then if peakl75_2 = 1 then peakl75 =
1;
if lead=0 then lead=0.1;
loglead = log(lead);
logpeak = log(peaklead);
logearly = log(meanlead6m_24m);
loglife = log(meanlead6m_concurrent);
run;

proc freq; tables peakl10 peakl75; run;

proc glm;
      class site;
      model wiscr10t = lead/ solution ss3;
      where site = "Boston";
run;

proc glm;
      class site;
      model wiscr10p = lead/ solution ss3;
      where site = "Boston";
run;

proc glm;
      class site;
      model wiscr10t = pbch2y/ solution ss3;
      where site = "Boston";
run;

proc glm;
      class site;
      model wiscr10p = pbch2y/ solution ss3;
      where site = "Boston";
run;

proc glm;
      class site;
      model iq = loglead site birthwt HOME momiq momeduc/ solution ss3;
run;


proc glm;
      class site;
      model iq = logpeak site birthwt HOME momiq momeduc/ solution ss3;
run;


proc glm;
      class site;
      model iq = logearly site birthwt HOME momiq momeduc/ solution ss3;
```

```
run;


proc glm;
      class site;
      model iq = loglife site birthwt HOME momiq momeduc/ solution ss3;
run;


proc glm;
      class site;
      model iq = lead site birthwt HOME momiq momeduc/ solution ss3;
where peakl10 = 1;
run;

proc glm;
      class site;
      model iq = lead site birthwt HOME momiq momeduc/ solution ss3;
where peakl10 = 0;
run;

proc glm;
      class site;
      model iq = lead site birthwt HOME momiq momeduc/ solution ss3;
where peakl75 = 1;
run;

proc glm;
      class site;
      model iq = lead site birthwt HOME momiq momeduc/ solution ss3;
where peakl75 = 0;
run;

proc sort; by peakl10; run;

proc univariate; var lead; by peakl10; run;

proc sort; by peakl75; run;

proc univariate; var lead; by peakl75; run;

/*The data steps and models below estimate the concurrent blood Pb-IQ
association for a log linear model, excluding one of the seven cohorts*/

data pooled.noBos; set pooled.Lanphearcorrected;
if site EQ "Boston" then delete;
run;

proc glm;
      class site;
      model iq = loglead site birthwt HOME momiq momeduc/ solution ss3;
run;

data pooled.noRoc; set pooled.Lanphearcorrected;
if site EQ "Rochester" then delete;
run;
```

```
proc glm;
      class site;
      model iq = loglead site birthwt HOME momiq momeduc/ solution ss3;
run;

data pooled.noCle; set pooled.Lanphearcorrected;
if site EQ "Cleveland" then delete;
run;

proc glm;
      class site;
      model iq = loglead site birthwt HOME momiq momeduc/ solution ss3;
run;

data pooled.noCin; set pooled.Lanphearcorrected;
if site EQ "Cincinnati" then delete;
run;

proc glm;
      class site;
      model iq = loglead site birthwt HOME momiq momeduc/ solution ss3;
run;

data pooled.noMC; set pooled.Lanphearcorrected;
if site EQ "Mexico" then delete;
run;

proc glm;
      class site;
      model iq = loglead site birthwt HOME momiq momeduc/ solution ss3;
run;

data pooled.noPir; set pooled.Lanphearcorrected;
if site EQ "PortPirie" then delete;
run;

proc glm;
      class site;
      model iq = loglead site birthwt HOME momiq momeduc/ solution ss3;
run;

data pooled.noYug; set pooled.Lanphearcorrected;
if site EQ "Yugoslavia" then delete;
run;

proc glm;
      class site;
      model iq = loglead site birthwt HOME momiq momeduc/ solution ss3;
run;
```

Output from Statistical Program

The SAS System

The FREQ Procedure

peakl10	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	1075	80.65	1075	80.65
1	258	19.35	1333	100.00

peakl75	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	1215	91.15	1215	91.15
1	118	8.85	1333	100.00

The GLM Procedure

Class Level Information

Class	Levels	Values
site	1	Boston

Number of Observations Read	116
Number of Observations Used	116

The SAS System

The GLM Procedure

Dependent Variable: wiscr10t IQ Child age 10 WISCR Total

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1522.11305	1522.11305	7.95	0.0057
Error	114	21830.80936	191.49833		
Corrected Total	115	23352.92241			

R-Square	Coeff Var	Root MSE	wiscr10t Mean
0.065179	11.93222	13.83829	115.9741

Source	DF	Type III SS	Mean Square	F Value	Pr > F
lead	1	1522.113050	1522.113050	7.95	0.0057

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	121.9329247	2.47346534	49.30	<.0001
lead	-0.9731371	0.34517001	-2.82	0.0057

The SAS System

The GLM Procedure

Class Level Information

Class	Levels	Values
site	1	Boston

Number of Observations Read	116
Number of Observations Used	116

The SAS System

The GLM Procedure

Dependent Variable: wiscr10p IQ Child age 10 WISCR Performance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	921.62895	921.62895	4.25	0.0415
Error	114	24705.33657	216.71348		
Corrected Total	115	25626.96552			

R-Square	Coeff Var	Root MSE	wiscr10p Mean
0.035963	12.42475	14.72119	118.4828

Source	DF	Type III SS	Mean Square	F Value	Pr > F
lead	1	921.6289488	921.6289488	4.25	0.0415

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	123.1194954	2.63127536	46.79	<.0001
lead	-0.7572314	0.36719226	-2.06	0.0415

The GLM Procedure

Class Level Information

Class	Levels	Values
site	1	Boston

Number of Observations Read	116
Number of Observations Used	115

The SAS System

The GLM Procedure

Dependent Variable: wiscr10t IQ Child age 10 WISCR Total

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	627.48956	627.48956	3.14	0.0791
Error	113	22580.80610	199.83014		
Corrected Total	114	23208.29565			

R-Square	Coeff Var	Root MSE	wiscr10t Mean
0.027037	12.17810	14.13613	116.0783

Source	DF	Type III SS	Mean Square	F Value	Pr > F
pbch2y	1	627.4895565	627.4895565	3.14	0.0791

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	120.1845551	2.66597270	45.08	<.0001
pbch2y	-0.4821070	0.27206377	-1.77	0.0791

The GLM Procedure

Class Level Information

Class	Levels	Values
site	1	Boston

Number of Observations Read	116
Number of Observations Used	115

The SAS System

The GLM Procedure

Dependent Variable: wiscr10p IQ Child age 10 WISCR Performance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1077.37320	1077.37320	4.99	0.0275
Error	113	24416.59201	216.07604		
Corrected Total	114	25493.96522			

R-Square	Coeff Var	Root MSE	wiscr10p Mean
0.042260	12.39602	14.69953	118.5826

Source	DF	Type III SS	Mean Square	F Value	Pr > F
pbch2y	1	1077.373204	1077.373204	4.99	0.0275

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	123.9631987	2.77222516	44.72	<.0001
pbch2y	-0.6317181	0.28290689	-2.23	0.0275

The GLM Procedure

Class Level Information

Class	Levels	Values
site	7	Boston Cincinnati Cleveland Mexico PortPirie Rochester Yugoslavia

Number of Observations Read	1333
Number of Observations Used	1333

The SAS System

The GLM Procedure

Dependent Variable: iq

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	327940.4682	29812.7698	214.79	<.0001
Error	1321	183352.3915	138.7982		
Corrected Total	1332	511292.8597			

R-Square	Coeff Var	Root MSE	iq Mean
0.641395	12.60802	11.78126	93.44261

Source	DF	Type III SS	Mean Square	F Value	Pr > F
loglead	1	3474.24421	3474.24421	25.03	<.0001
site	6	66081.41209	11013.56868	79.35	<.0001
birthwt	1	2621.37601	2621.37601	18.89	<.0001
home	1	10179.85113	10179.85113	73.34	<.0001
momiq	1	12795.37214	12795.37214	92.19	<.0001
momeduc	1	967.67984	967.67984	6.97	0.0084

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	27.04732556	B	3.76475269	7.18	<.0001
loglead	-2.65193533		0.53005952	-5.00	<.0001
site Boston	17.65819126	B	1.90163535	9.29	<.0001
site Cincinnati	12.84631794	B	1.31942912	9.74	<.0001
site Cleveland	11.83109308	B	1.43718597	8.23	<.0001
site Mexico	25.64990185	B	1.51558784	16.92	<.0001
site PortPirie	22.00255364	B	1.21043737	18.18	<.0001
site Rochester	7.11903041	B	1.48288723	4.80	<.0001
site Yugoslavia	0.00000000	B	.	.	.
birthwt	0.00286312		0.00065882	4.35	<.0001
home	0.52537002		0.06134603	8.56	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
momiq	0.28757382	0.02995124	9.60	<.0001
momeduc	0.42930586	0.16258963	2.64	0.0084

Note: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

The GLM Procedure

Class Level Information

Class	Levels	Values
site	7	Boston Cincinnati Cleveland Mexico PortPirie Rochester Yugoslavia

Number of Observations Read	1333
Number of Observations Used	1333

The SAS System

The GLM Procedure

Dependent Variable: iq

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	327276.4058	29752.4005	213.58	<.0001
Error	1321	184016.4540	139.3009		
Corrected Total	1332	511292.8597			

R-Square	Coeff Var	Root MSE	iq Mean
0.640096	12.63083	11.80258	93.44261

Source	DF	Type III SS	Mean Square	F Value	Pr > F
logpeak	1	2810.18175	2810.18175	20.17	<.0001
site	6	69681.25928	11613.54321	83.37	<.0001
birthwt	1	2606.40484	2606.40484	18.71	<.0001
home	1	10407.36979	10407.36979	74.71	<.0001
momiq	1	13373.90809	13373.90809	96.01	<.0001
momeduc	1	1007.34017	1007.34017	7.23	0.0073

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	27.91970929	B	4.00880180	6.96	<.0001
logpeak	-2.85587349		0.63584122	-4.49	<.0001
site Boston	18.36212688	B	1.88672487	9.73	<.0001
site Cincinnati	14.06412178	B	1.28253969	10.97	<.0001
site Cleveland	11.39642871	B	1.44278400	7.90	<.0001
site Mexico	26.51500475	B	1.49312461	17.76	<.0001
site PortPirie	22.91283492	B	1.23280694	18.59	<.0001
site Rochester	8.01829313	B	1.43377664	5.59	<.0001
site Yugoslavia	0.00000000	B	.	.	.
birthwt	0.00285535		0.00066011	4.33	<.0001
home	0.53083774		0.06141412	8.64	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
momiq	0.29342850	0.02994677	9.80	<.0001
momeduc	0.43788970	0.16283718	2.69	0.0073

Note: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

The GLM Procedure

Class Level Information

Class	Levels	Values
site	7	Boston Cincinnati Cleveland Mexico PortPirie Rochester Yugoslavia

Number of Observations Read	1333
Number of Observations Used	1308

The SAS System

The GLM Procedure

Dependent Variable: iq

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	323379.5236	29398.1385	212.53	<.0001
Error	1296	179272.5926	138.3276		
Corrected Total	1307	502652.1162			

R-Square	Coeff Var	Root MSE	iq Mean
0.643347	12.58240	11.76128	93.47401

Source	DF	Type III SS	Mean Square	F Value	Pr > F
logearly	1	1888.26101	1888.26101	13.65	0.0002
site	6	68546.00714	11424.33452	82.59	<.0001
birthwt	1	2390.13312	2390.13312	17.28	<.0001
home	1	10145.18428	10145.18428	73.34	<.0001
momiq	1	13737.96496	13737.96496	99.31	<.0001
momeduc	1	1083.28832	1083.28832	7.83	0.0052

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	24.63768949	B	3.73034439	6.60	<.0001
logearly	-2.20591751		0.59705275	-3.69	0.0002
site Boston	18.15626038	B	1.91778407	9.47	<.0001
site Cincinnati	14.27745674	B	1.27856877	11.17	<.0001
site Cleveland	11.46422442	B	1.49254021	7.68	<.0001
site Mexico	26.84805362	B	1.48914619	18.03	<.0001
site PortPirie	23.05313333	B	1.24749405	18.48	<.0001
site Rochester	8.42417190	B	1.42756207	5.90	<.0001
site Yugoslavia	0.00000000	B	.	.	.
birthwt	0.00275146		0.00066192	4.16	<.0001
home	0.52954367		0.06183385	8.56	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
momiq	0.29979643	0.03008290	9.97	<.0001
momeduc	0.45768747	0.16355034	2.80	0.0052

Note: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

The GLM Procedure

Class Level Information

Class	Levels	Values
site	7	Boston Cincinnati Cleveland Mexico PortPirie Rochester Yugoslavia

Number of Observations Read	1333
Number of Observations Used	1333

The GLM Procedure

Dependent Variable: iq

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	327804.7469	29800.4315	214.54	<.0001
Error	1321	183488.1128	138.9009		
Corrected Total	1332	511292.8597			

R-Square	Coeff Var	Root MSE	iq Mean
0.641129	12.61269	11.78562	93.44261

Source	DF	Type III SS	Mean Square	F Value	Pr > F
loglife	1	3338.52290	3338.52290	24.04	<.0001
site	6	69505.74205	11584.29034	83.40	<.0001
birthwt	1	2517.77496	2517.77496	18.13	<.0001
home	1	10236.98947	10236.98947	73.70	<.0001
momiq	1	13381.00079	13381.00079	96.33	<.0001
momeduc	1	961.34341	961.34341	6.92	0.0086

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	28.24337513	B	3.92416837	7.20	<.0001
loglife	-3.13865602		0.64020506	-4.90	<.0001
site Boston	17.45724787	B	1.91192335	9.13	<.0001
site Cincinnati	13.56169824	B	1.29159931	10.50	<.0001
site Cleveland	11.69697796	B	1.43791274	8.13	<.0001
site Mexico	26.13585581	B	1.49932438	17.43	<.0001
site PortPirie	22.78026468	B	1.22364122	18.62	<.0001
site Rochester	7.22001411	B	1.48020263	4.88	<.0001
site Yugoslavia	0.00000000	B	.	.	.
birthwt	0.00280762		0.00065945	4.26	<.0001
home	0.52671510		0.06135390	8.58	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
momiq	0.29347023	0.02990008	9.82	<.0001
momeduc	0.42795513	0.16267152	2.63	0.0086

Note: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

The GLM Procedure

Class Level Information

Class	Levels	Values
site	6	Boston Cincinnati Cleveland Mexico Rochester Yugoslavia

Number of Observations Read	258
Number of Observations Used	258

The SAS System

The GLM Procedure

Dependent Variable: iq

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	75391.2023	7539.1202	47.95	<.0001
Error	247	38835.9140	157.2304		
Corrected Total	257	114227.1163			

R-Square	Coeff Var	Root MSE	iq Mean
0.660011	13.09652	12.53916	95.74419

Source	DF	Type III SS	Mean Square	F Value	Pr > F
lead	1	446.063013	446.063013	2.84	0.0934
site	5	8345.359497	1669.071899	10.62	<.0001
birthwt	1	2038.632694	2038.632694	12.97	0.0004
home	1	906.185584	906.185584	5.76	0.0171
momiq	1	3043.925976	3043.925976	19.36	<.0001
momeduc	1	260.774911	260.774911	1.66	0.1990

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	18.18613910	B	8.59218349	2.12	0.0353
lead	-0.76511302		0.45425088	-1.68	0.0934
site Boston	18.85551296	B	4.09764496	4.60	<.0001
site Cincinnati	10.80388499	B	3.63189262	2.97	0.0032
site Cleveland	17.27306085	B	4.78283355	3.61	0.0004
site Mexico	23.71313388	B	3.63731021	6.52	<.0001
site Rochester	6.72724026	B	2.92871503	2.30	0.0225
site Yugoslavia	0.00000000	B	.	.	.
birthwt	0.00602932		0.00167443	3.60	0.0004
home	0.39015482		0.16251621	2.40	0.0171
momiq	0.31503186		0.07159880	4.40	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
momeduc	0.55327718	0.42961372	1.29	0.1990

Note: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

The GLM Procedure

Class Level Information

Class	Levels	Values
site	7	Boston Cincinnati Cleveland Mexico PortPirie Rochester Yugoslavia

Number of Observations Read	1075
Number of Observations Used	1075

The SAS System

The GLM Procedure

Dependent Variable: iq

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	252365.1647	22942.2877	170.54	<.0001
Error	1063	143005.8827	134.5305		
Corrected Total	1074	395371.0474			

R-Square	Coeff Var	Root MSE	iq Mean
0.638300	12.48649	11.59873	92.89023

Source	DF	Type III SS	Mean Square	F Value	Pr > F
lead	1	1177.57910	1177.57910	8.75	0.0032
site	6	50057.16148	8342.86025	62.01	<.0001
birthwt	1	1209.19905	1209.19905	8.99	0.0028
home	1	9026.17315	9026.17315	67.09	<.0001
momiq	1	9548.68378	9548.68378	70.98	<.0001
momeduc	1	793.78352	793.78352	5.90	0.0153

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	24.20220118	B	3.86515250	6.26	<.0001
lead	-0.13305168		0.04497132	-2.96	0.0032
site Boston	17.80470393	B	2.30699971	7.72	<.0001
site Cincinnati	13.35800457	B	1.53156221	8.72	<.0001
site Cleveland	11.17455053	B	1.58088679	7.07	<.0001
site Mexico	26.43625875	B	1.74854717	15.12	<.0001
site PortPirie	21.98066621	B	1.34566292	16.33	<.0001
site Rochester	7.07573613	B	1.88609692	3.75	0.0002
site Yugoslavia	0.00000000	B	.	.	.
birthwt	0.00215064		0.00071735	3.00	0.0028
home	0.54576743		0.06662943	8.19	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
momiq	0.28269110	0.03355449	8.42	<.0001
momeduc	0.42897703	0.17660106	2.43	0.0153

Note: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

The GLM Procedure

Class Level Information

Class	Levels	Values
site	6	Boston Cincinnati Cleveland Mexico Rochester Yugoslavia

Number of Observations Read	118
Number of Observations Used	118

The SAS System

The GLM Procedure

Dependent Variable: iq

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	32060.86131	3206.08613	17.10	<.0001
Error	107	20060.90141	187.48506		
Corrected Total	117	52121.76271			

R-Square	Coeff Var	Root MSE	iq Mean
0.615115	13.92620	13.69252	98.32203

Source	DF	Type III SS	Mean Square	F Value	Pr > F
lead	1	1208.290980	1208.290980	6.44	0.0126
site	5	2414.540703	482.908141	2.58	0.0306
birthwt	1	1312.897431	1312.897431	7.00	0.0094
home	1	1684.201650	1684.201650	8.98	0.0034
momiq	1	203.024510	203.024510	1.08	0.3004
momeduc	1	372.404312	372.404312	1.99	0.1616

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	25.71242076	B	13.97200329	1.84	0.0685
lead	-2.52649591		0.99521329	-2.54	0.0126
site Boston	6.68339913	B	7.20701358	0.93	0.3558
site Cincinnati	28.61890969	B	14.93280507	1.92	0.0580
site Cleveland	-7.91036480	B	15.64398146	-0.51	0.6141
site Mexico	10.97187362	B	7.11090999	1.54	0.1258
site Rochester	-3.90103867	B	5.82471299	-0.67	0.5045
site Yugoslavia	0.00000000	B	.	.	.
birthwt	0.00678705		0.00256477	2.65	0.0094
home	0.86121562		0.28734139	3.00	0.0034
momiq	0.12432473		0.11947214	1.04	0.3004

Parameter	Estimate	Standard Error	t Value	Pr > |t|
momeduc	1.04376665	0.74059265	1.41	0.1616

Note: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

The GLM Procedure

Class Level Information

Class	Levels	Values
site	7	Boston Cincinnati Cleveland Mexico PortPirie Rochester Yugoslavia

Number of Observations Read	1215
Number of Observations Used	1215

The GLM Procedure

Dependent Variable: iq

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	295595.2682	26872.2971	201.42	<.0001
Error	1203	160493.5433	133.4111		
Corrected Total	1214	456088.8115			

R-Square	Coeff Var	Root MSE	iq Mean
0.648109	12.42393	11.55037	92.96872

Source	DF	Type III SS	Mean Square	F Value	Pr > F
lead	1	1856.41937	1856.41937	13.92	0.0002
site	6	59575.72492	9929.28749	74.43	<.0001
birthwt	1	1731.15356	1731.15356	12.98	0.0003
home	1	8914.66922	8914.66922	66.82	<.0001
momiq	1	12447.67461	12447.67461	93.30	<.0001
momeduc	1	871.14627	871.14627	6.53	0.0107

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	23.53661203	B	3.56150039	6.61	<.0001
lead	-0.15329940		0.04109589	-3.73	0.0002
site Boston	18.19392517	B	2.03397309	8.95	<.0001
site Cincinnati	13.11021920	B	1.37249065	9.55	<.0001
site Cleveland	11.72102156	B	1.45049515	8.08	<.0001
site Mexico	26.48978529	B	1.57859524	16.78	<.0001
site PortPirie	21.84772381	B	1.23476009	17.69	<.0001
site Rochester	6.92986243	B	1.61490719	4.29	<.0001
site Yugoslavia	0.00000000	B	.	.	.
birthwt	0.00245251		0.00068083	3.60	0.0003
home	0.50965282		0.06234732	8.17	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
momiq	0.30003407	0.03106150	9.66	<.0001
momeduc	0.42343226	0.16570453	2.56	0.0107

Note: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

The UNIVARIATE Procedure
Variable: lead
peakl10=0

Moments

N	1075	**Sum Weights**	1075
Mean	14.0349963	**Sum Observations**	15087.621
Std Deviation	9.73241339	**Variance**	94.7198704
Skewness	1.92115744	**Kurtosis**	4.82297042
Uncorrected SS	313483.845	**Corrected SS**	101729.141
Coeff Variation	69.3438972	**Std Error Mean**	0.29683583

Basic Statistical Measures

Location		**Variability**	
Mean	14.03500	**Std Deviation**	9.73241
Median	11.10000	**Variance**	94.71987
Mode	12.00000	**Range**	71.60000
		Interquartile Range	9.44571

Tests for Location: Mu0=0

Test		**Statistic**	**p Value**	
Student's t	**t**	47.28202	**Pr > |t|**	<.0001
Sign	**M**	537.5	**Pr >= |M|**	<.0001
Signed Rank	**S**	289175	**Pr >= |S|**	<.0001

Quantiles (Definition 5)

Level	**Quantile**
100% Max	71.70000
99%	48.90000
95%	35.50000
90%	26.50000
75% Q3	17.04571
50% Median	11.10000
25% Q1	7.60000
10%	5.20000
5%	4.37780
1%	2.00857
0% Min	0.10000

Extreme Observations

Lowest	**Highest**

Value	Obs	Value	Obs
0.1	691	56.3	476
0.8	699	60.3	564
0.9	725	63.6	546
1.1	721	68.3	481
1.4	694	71.7	553

The UNIVARIATE Procedure
Variable: lead
peakl10=1

Moments

N	258	**Sum Weights**	258
Mean	4.40229389	**Sum Observations**	1135.79182
Std Deviation	2.04490428	**Variance**	4.18163352
Skewness	0.30846374	**Kurtosis**	-0.3937443
Uncorrected SS	6074.76923	**Corrected SS**	1074.67981
Coeff Variation	46.4508806	**Std Error Mean**	0.12731018

Basic Statistical Measures

Location		**Variability**	
Mean	4.402294	**Std Deviation**	2.04490
Median	4.300000	**Variance**	4.18163
Mode	4.000000	**Range**	9.70000
		Interquartile Range	2.79204

Tests for Location: Mu0=0

Test		**Statistic**	**p Value**	
Student's t	**t**	34.57928	**Pr > |t|**	<.0001
Sign	**M**	129	**Pr >= |M|**	<.0001
Signed Rank	**S**	16705.5	**Pr >= |S|**	<.0001

Quantiles (Definition 5)

Level	**Quantile**
100% Max	9.80000
99%	9.50000
95%	8.00000
90%	7.40000
75% Q3	5.79204
50% Median	4.30000
25% Q1	3.00000
10%	1.80000
5%	1.40000
1%	0.10000
0% Min	0.10000

Extreme Observations

Lowest	**Highest**

Value	Obs	Value	Obs
0.1	1290	9.0	1271
0.1	1288	9.0	1328
0.1	1266	9.5	1284
0.5	1257	9.7	1182
0.9	1296	9.8	1259

The UNIVARIATE Procedure
Variable: lead
peakl75=0

Moments

N	1215	**Sum Weights**	1215
Mean	13.0307607	**Sum Observations**	15832.3743
Std Deviation	9.59106571	**Variance**	91.9885414
Skewness	1.99140977	**Kurtosis**	5.20797771
Uncorrected SS	317981.971	**Corrected SS**	111674.089
Coeff Variation	73.6032676	**Std Error Mean**	0.27515584

Basic Statistical Measures

Location		**Variability**	
Mean	13.03076	**Std Deviation**	9.59107
Median	10.10000	**Variance**	91.98854
Mode	8.00000	**Range**	71.60000
		Interquartile Range	9.43328

Tests for Location: Mu0=0

Test		**Statistic**		**p Value**
Student's t	**t**	47.35775	**Pr > |t|**	<.0001
Sign	**M**	607.5	**Pr >= |M|**	<.0001
Signed Rank	**S**	369360	**Pr >= |S|**	<.0001

Quantiles (Definition 5)

Level	**Quantile**
100% Max	71.70000
99%	47.40000
95%	34.20000
90%	24.60000
75% Q3	16.00000
50% Median	10.10000
25% Q1	6.56672
10%	4.70000
5%	3.69096
1%	1.78971
0% Min	0.10000

Extreme Observations

Lowest	**Highest**

Value	Obs	Value	Obs
0.1	1181	56.3	476
0.1	1168	60.3	564
0.1	691	63.6	546
0.5	1165	68.3	481
0.8	699	71.7	553

The UNIVARIATE Procedure
Variable: lead
peakl75=1

Moments

N	118	**Sum Weights**	118
Mean	3.31388564	**Sum Observations**	391.038506
Std Deviation	1.54915623	**Variance**	2.39988502
Skewness	0.55062293	**Kurtosis**	-0.1167017
Uncorrected SS	1576.64344	**Corrected SS**	280.786548
Coeff Variation	46.7474257	**Std Error Mean**	0.14261139

Basic Statistical Measures

Location		Variability	
Mean	3.313886	**Std Deviation**	1.54916
Median	3.150000	**Variance**	2.39989
Mode	1.500000	**Range**	7.30000
		Interquartile Range	2.30000

Note: The mode displayed is the smallest of 4 modes with a count of 6.

Tests for Location: Mu0=0

Test		Statistic		p Value
Student's t	**t**	23.23717	**Pr > |t|**	<.0001
Sign	**M**	59	**Pr >= |M|**	<.0001
Signed Rank	**S**	3510.5	**Pr >= |S|**	<.0001

Quantiles (Definition 5)

Level	Quantile
100% Max	7.40
99%	7.10
95%	6.70
90%	5.30
75% Q3	4.40
50% Median	3.15
25% Q1	2.10
10%	1.50
5%	1.10
1%	0.90
0% Min	0.10

Extreme Observations

Lowest		Highest	
Value	**Obs**	**Value**	**Obs**
0.1	1323	6.8	1244
0.9	1328	7.0	1227
1.0	1305	7.0	1249
1.1	1302	7.1	1317
1.1	1279	7.4	1325

The GLM Procedure

Class Level Information

Class	Levels	Values
site	6	Cincinnati Cleveland Mexico PortPirie Rochester Yugoslavia

Number of Observations Read	1217
Number of Observations Used	1217

The SAS System

The GLM Procedure

Dependent Variable: iq

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	236289.1250	23628.9125	173.27	<.0001
Error	1206	164459.3614	136.3676		
Corrected Total	1216	400748.4864			

R-Square	Coeff Var	Root MSE	iq Mean
0.589620	12.83549	11.67766	90.97946

Source	DF	Type III SS	Mean Square	F Value	Pr > F
loglead	1	3316.01053	3316.01053	24.32	<.0001
site	5	64980.50802	12996.10160	95.30	<.0001
birthwt	1	2064.61424	2064.61424	15.14	0.0001
home	1	9235.31461	9235.31461	67.72	<.0001
momiq	1	12385.71930	12385.71930	90.83	<.0001
momeduc	1	613.66271	613.66271	4.50	0.0341

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	28.31031692	B	4.05184024	6.99	<.0001
loglead	-2.94149749		0.59650787	-4.93	<.0001
site Cincinnati	13.04475988	B	1.33636189	9.76	<.0001
site Cleveland	12.27990700	B	1.44363380	8.51	<.0001
site Mexico	25.62621387	B	1.51767586	16.89	<.0001
site PortPirie	22.18590267	B	1.20511010	18.41	<.0001
site Rochester	7.11859842	B	1.52466887	4.67	<.0001
site Yugoslavia	0.00000000	B	.	.	.
birthwt	0.00266431		0.00068473	3.89	0.0001
home	0.50824816		0.06175976	8.23	<.0001
momiq	0.30374683		0.03187181	9.53	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
momeduc	0.34980816	0.16490002	2.12	0.0341

Note: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

The GLM Procedure

Class Level Information

Class	Levels	Values
site	6	Boston Cincinnati Cleveland Mexico PortPirie Yugoslavia

Number of Observations Read	1151
Number of Observations Used	1151

The SAS System

The GLM Procedure

Dependent Variable: iq

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	301590.5468	30159.0547	219.39	<.0001
Error	1140	156711.1509	137.4659		
Corrected Total	1150	458301.6977			

R-Square	Coeff Var	Root MSE	iq Mean
0.658061	12.36916	11.72459	94.78888

Source	DF	Type III SS	Mean Square	F Value	Pr > F
loglead	1	2322.19475	2322.19475	16.89	<.0001
site	5	59773.32662	11954.66532	86.96	<.0001
birthwt	1	2608.68551	2608.68551	18.98	<.0001
home	1	10457.29282	10457.29282	76.07	<.0001
momiq	1	9406.63788	9406.63788	68.43	<.0001
momeduc	1	739.22161	739.22161	5.38	0.0206

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	26.07614527	B	3.97911701	6.55	<.0001
loglead	-2.31061277		0.56217998	-4.11	<.0001
site Boston	18.04273067	B	1.97692421	9.13	<.0001
site Cincinnati	12.77102289	B	1.33566531	9.56	<.0001
site Cleveland	11.18448251	B	1.46074838	7.66	<.0001
site Mexico	25.80176014	B	1.52495154	16.92	<.0001
site PortPirie	21.62285075	B	1.23691384	17.48	<.0001
site Yugoslavia	0.00000000	B	.	.	.
birthwt	0.00308899		0.00070909	4.36	<.0001
home	0.58105614		0.06662021	8.72	<.0001
momiq	0.26364705		0.03187155	8.27	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
momeduc	0.39387949	0.16985313	2.32	0.0206

Note: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

The GLM Procedure

Class Level Information

Class	Levels	Values
site	6	Boston Cincinnati Mexico PortPirie Rochester Yugoslavia

Number of Observations Read	1173
Number of Observations Used	1173

The GLM Procedure

Dependent Variable: iq

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	308275.4062	30827.5406	234.54	<.0001
Error	1162	152729.8828	131.4371		
Corrected Total	1172	461005.2890			

R-Square	Coeff Var	Root MSE	iq Mean
0.668703	12.14944	11.46460	94.36317

Source	DF	Type III SS	Mean Square	F Value	Pr > F
loglead	1	3022.54666	3022.54666	23.00	<.0001
site	5	65075.88660	13015.17732	99.02	<.0001
birthwt	1	2307.57510	2307.57510	17.56	<.0001
home	1	6986.65200	6986.65200	53.16	<.0001
momiq	1	11915.16399	11915.16399	90.65	<.0001
momeduc	1	770.11737	770.11737	5.86	0.0156

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	27.51857675	B	3.87345880	7.10	<.0001
loglead	-2.54225360		0.53014090	-4.80	<.0001
site Boston	18.55257917	B	1.91467978	9.69	<.0001
site Cincinnati	13.24172997	B	1.30690892	10.13	<.0001
site Mexico	26.05459883	B	1.48350394	17.56	<.0001
site PortPirie	22.59583498	B	1.20903911	18.69	<.0001
site Rochester	7.50313658	B	1.46561772	5.12	<.0001
site Yugoslavia	0.00000000	B	.	.	.
birthwt	0.00285799		0.00068209	4.19	<.0001
home	0.47427309		0.06505083	7.29	<.0001
momiq	0.29944622		0.03145052	9.52	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
momeduc	0.40255200	0.16630391	2.42	0.0156

Note: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

The GLM Procedure

Class Level Information

Class	Levels	Values
site	6	Boston Cleveland Mexico PortPirie Rochester Yugoslavia

Number of Observations Read	1112
Number of Observations Used	1112

The SAS System

The GLM Procedure

Dependent Variable: iq

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	313841.9568	31384.1957	218.57	<.0001
Error	1101	158093.1790	143.5905		
Corrected Total	1111	471935.1358			

R-Square	Coeff Var	Root MSE	iq Mean
0.665011	12.65061	11.98293	94.72212

Source	DF	Type III SS	Mean Square	F Value	Pr > F
loglead	1	3321.62903	3321.62903	23.13	<.0001
site	5	59842.10955	11968.42191	83.35	<.0001
birthwt	1	2357.38692	2357.38692	16.42	<.0001
home	1	10370.91496	10370.91496	72.23	<.0001
momiq	1	10750.08253	10750.08253	74.87	<.0001
momeduc	1	1078.77503	1078.77503	7.51	0.0062

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	25.48075164	B	4.05088278	6.29	<.0001
loglead	-2.76180365		0.57422242	-4.81	<.0001
site Boston	16.22337927	B	2.00273592	8.10	<.0001
site Cleveland	11.13427107	B	1.49803361	7.43	<.0001
site Mexico	25.09169853	B	1.55566677	16.13	<.0001
site PortPirie	21.17719673	B	1.27218362	16.65	<.0001
site Rochester	6.68369193	B	1.54435902	4.33	<.0001
site Yugoslavia	0.00000000	B	.	.	.
birthwt	0.00292387		0.00072162	4.05	<.0001
home	0.59096264		0.06953675	8.50	<.0001
momiq	0.27935355		0.03228577	8.65	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
momeduc	0.47313581	0.17261689	2.74	0.0062

Note: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

The GLM Procedure

Class Level Information

Class	Levels	Values
site	6	Boston Cincinnati Cleveland PortPirie Rochester Yugoslavia

Number of Observations Read	1234
Number of Observations Used	1234

The SAS System

The GLM Procedure

Dependent Variable: iq

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	305942.1337	30594.2134	218.46	<.0001
Error	1223	171274.3136	140.0444		
Corrected Total	1233	477216.4473			

R-Square	Coeff Var	Root MSE	iq Mean
0.641097	12.82310	11.83404	92.28687

Source	DF	Type III SS	Mean Square	F Value	Pr > F
loglead	1	3476.10559	3476.10559	24.82	<.0001
site	5	45483.33503	9096.66701	64.96	<.0001
birthwt	1	2414.20185	2414.20185	17.24	<.0001
home	1	10341.08090	10341.08090	73.84	<.0001
momiq	1	11780.92409	11780.92409	84.12	<.0001
momeduc	1	1584.80597	1584.80597	11.32	0.0008

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	25.20951687	B	3.90233377	6.46	<.0001
loglead	-2.71812947		0.54557762	-4.98	<.0001
site Boston	16.01877770	B	1.96826866	8.14	<.0001
site Cincinnati	12.29350792	B	1.34303009	9.15	<.0001
site Cleveland	11.24709835	B	1.46550263	7.67	<.0001
site PortPirie	21.35910778	B	1.23659062	17.27	<.0001
site Rochester	6.40031930	B	1.51516383	4.22	<.0001
site Yugoslavia	0.00000000	B	.	.	.
birthwt	0.00283174		0.00068202	4.15	<.0001
home	0.55594817		0.06469701	8.59	<.0001
momiq	0.28421399		0.03098765	9.17	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
momeduc	0.59716095	0.17751548	3.36	0.0008

Note: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

The GLM Procedure

Class Level Information

Class	Levels	Values
site	6	Boston Cincinnati Cleveland Mexico Rochester Yugoslavia

Number of Observations Read	1009
Number of Observations Used	1009

The SAS System

The GLM Procedure

Dependent Variable: iq

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	246690.2118	24669.0212	180.55	<.0001
Error	998	136358.2758	136.6315		
Corrected Total	1008	383048.4876			

R-Square	Coeff Var	Root MSE	iq Mean
0.644018	13.07309	11.68895	89.41229

Source	DF	Type III SS	Mean Square	F Value	Pr > F
loglead	1	3223.85781	3223.85781	23.60	<.0001
site	5	45113.93818	9022.78764	66.04	<.0001
birthwt	1	2502.40199	2502.40199	18.31	<.0001
home	1	8590.24972	8590.24972	62.87	<.0001
momiq	1	7888.02907	7888.02907	57.73	<.0001
momeduc	1	1182.19474	1182.19474	8.65	0.0033

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	28.71600442	B	4.05775291	7.08	<.0001
loglead	-2.69462287		0.55473495	-4.86	<.0001
site Boston	18.62337754	B	1.96821003	9.46	<.0001
site Cincinnati	12.30165902	B	1.33582155	9.21	<.0001
site Cleveland	11.27614573	B	1.46050926	7.72	<.0001
site Mexico	25.73828816	B	1.51617881	16.98	<.0001
site Rochester	6.67150502	B	1.49897680	4.45	<.0001
site Yugoslavia	0.00000000	B	.	.	.
birthwt	0.00323999		0.00075708	4.28	<.0001
home	0.52255782		0.06590327	7.93	<.0001
momiq	0.25030865		0.03294330	7.60	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
momeduc	0.48953177	0.16642243	2.94	0.0033

Note: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

The GLM Procedure

Class Level Information

Class	Levels	Values
site	6	Boston Cincinnati Cleveland Mexico PortPirie Rochester

Number of Observations Read	1102
Number of Observations Used	1102

The GLM Procedure

Dependent Variable: iq

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	208387.6679	20838.7668	143.06	<.0001
Error	1091	158916.8439	145.6616		
Corrected Total	1101	367304.5118			

R-Square	Coeff Var	Root MSE	iq Mean
0.567343	12.38230	12.06904	97.47005

Source	DF	Type III SS	Mean Square	F Value	Pr > F
loglead	1	2251.58532	2251.58532	15.46	<.0001
site	5	21482.32642	4296.46528	29.50	<.0001
birthwt	1	1496.10389	1496.10389	10.27	0.0014
home	1	5461.31821	5461.31821	37.49	<.0001
momiq	1	12867.67901	12867.67901	88.34	<.0001
momeduc	1	130.12532	130.12532	0.89	0.3448

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	36.99610669	B	4.36665378	8.47	<.0001
loglead	-2.65025139		0.67408623	-3.93	<.0001
site Boston	10.78809989	B	2.16658747	4.98	<.0001
site Cincinnati	5.83336114	B	1.30120035	4.48	<.0001
site Cleveland	5.27530315	B	1.68870552	3.12	0.0018
site Mexico	18.19553876	B	1.68636293	10.79	<.0001
site PortPirie	14.88475591	B	1.73534651	8.58	<.0001
site Rochester	0.00000000	B	.	.	.
birthwt	0.00242194		0.00075571	3.20	0.0014
home	0.43765670		0.07147554	6.12	<.0001
momiq	0.33599202		0.03574798	9.40	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
momeduc	0.22179064	0.23465774	0.95	0.3448

Note: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

Derivation of IQ Decrements over Various Blood Pb Ranges

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Model coefficient for concurrent blood Pb	lower confidence limit	upper confidence limit	minimum blood Pb in range of interest	maximum blood Pb in range of interest	ln of minimum blood Pb	ln of maximum blood Pb	difference in ln of blood Pb	difference in maximum and minimum blood Pb of interest	slope over the blood Pb range of interest	lower confidence limit for slope over the blood Pb range of interest	upper confidence limit for slope over the blood Pb range of interest	IQ decrement over the blood Pb range of interest	lower bound of absolute IQ decrement	Upper bound of IQ decrement
-2.65	-3.69	-1.61	2.4	30	0.88	3.40	2.53	27.6	-0.24	-0.34	-0.15	6.7	4.1	9.3
-2.65	-3.69	-1.61	2.4	10	0.88	2.30	1.43	7.6	-0.50	-0.69	-0.30	3.8	2.3	5.3
-2.65	-3.69	-1.61	10	20	2.30	3.00	0.69	10	-0.18	-0.26	-0.11	1.8	1.1	2.6
-2.65	-3.69	-1.61	20	30	3.00	3.40	0.41	10	-0.11	-0.15	-0.07	1.1	0.7	1.5
Formula for cell					=LN(D)	=LN(E)	=G-F	=E-D	=A*H/I	=B*H/I	=C*H/I	=-(J*I)	=-(L*I)	=-(K*I)

ATTACHMENT 2
Emails from R. Hornung (May 1, 2014) and B. Lanphear (February 24, 2014)

Kirrane, Ellen

From: Hornung, Richard (Rick) [Richard.Hornung@cchmc.org]
Sent: Thursday, May 01, 2014 10:03 AM
To: Kirrane, Ellen
Cc: Bruce Lanphear; Patel, Molini
Subject: RE: Lanphear et al. 2005

Hi Ellen

I was able to contact Bruce and also Jane Khoury who assembled the pooled data set. We were able to check older data files and we did find that the blood Pb values for Boston for children at 6, 12, 18, and 24 months had a minimum of 2.0. Dr. Khoury did not recall adding 1.0 to the antilog of the log-transformed data, but we agree that it appears that the correction of subtracting 2.0 from these values for the Boston cohort was appropriate.

Regards,
Rick

Kirrane, Ellen

From: Bruce Lanphear [bpl3@sfu.ca]
Sent: Monday, February 24, 2014 5:27 PM
To: Kirrane, Ellen
Cc: Richard Hornung (Rick); Patel, Molini
Subject: Re: Conference call and follow-up

Ellen and others:

I am available on March 4th from 7:00 am to 9:00 am PT (I am assuming you meant 10:00 am to 12:00 pm ET, right?).

We did verify that we inadvertently switched full-scale IQ with performance IQ. We also verified that it didn't change the primary results.

Rick can make sure we use the correct data.

Best regards,

Bruce