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DIRECTOR OF HEALTH AND SAFETY

May 25, 1967

To: All Members of the Lead Health and Safety Committee

Re: AIHA Blood Lead Comparison Study

Attached you will find a copy of a paper, presented at the 1967 American Industrial Hygiene Conference, which describes the blood-lead comparison study conducted by the Analytical Chemistry Section of the American Industrial Hygiene Association.

You will note that the results of this study indicate serious disagreements both between laboratories and within the same laboratory. Accordingly, it has been decided that a second survey is necessary to resolve these differences and to eliminate any question of uniformity which might have been introduced by mixing numbers of small samples to make up the composites used in the first reference specimens.

For your information, our organization is joining in providing financial support for the repeat study. In addition, we plan to give our member companies sufficient advance notice, so that any who wish to may participate in the second survey.

James C. Roumas, Jr.

James C. Roumas
Assistant Director
Health and Safety

JCR/jv
Att.

Look Ahead with Lead

AIHA BLOOD-LEAD COMPARISON STUDY

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BLOOD LEAD COMPARISON STUDY

AIHA ANALYTICAL CHEMISTRY COMMITTEE

Introduction

The best single analytical test for determining a worker's exposure to lead is a blood lead analysis. This test has proven effective in the prevention of clinical lead poisoning. Normally a worker can be removed from further industrial exposure to lead before clinical symptoms of poisoning become evident. Furthermore, in many plants particularly the ones employing only a small number of employees, a physician is brought into the industrial medicine program for the first time since it is necessary for him to draw the blood for lead analysis.

Accuracy is a prime requisite if blood lead levels of industrial workers are to be used as an index of exposure and workers are to be transferred to non-lead exposure jobs as a result of this analytical test. If lead levels are erroneously reported low, workers are given a false sense of security and excessive lead exposures will continue with eventual cases of clinical lead poisoning. If lead levels are erroneously reported high, workers are given a false scare of potential poisoning. They are unnecessarily transferred to non-lead exposure jobs most often with the loss of earnings. The potential production and industrial relation problems which industry then faces should not be minimized. The blood lead test can be of tremendous value to both industry and labor, but such tests MUST BE ACCURATE.

In order that this study be as realistic as possible, blood from workers with industrial exposure to lead was accumulated and furnished for analysis to participating laboratories without artificially spiking these samples with an inorganic lead compound. The purpose of this study was actually two-fold: it afforded each participating laboratory an opportunity to compare its results with those of other laboratories analyzing similar blood samples; and, it gave a broad prospective to the efficacy of blood-lead analysis.

Preparation of Samples

Since only a small portion of a blood specimen as received is required for lead analysis as performed in the Indiana Industrial Hygiene Laboratory, that blood which remained was poured from its Vacutainer and bottled according to the level of lead found in the sample and the anti-coagulant present, be it potassium oxalate or EDTA. The blood in these bottles was kept refrigerated and varied in age from one week to more than one year.

Lead analyses were made on the blood in each storage container and an estimate was made of the volume of blood stored in each container. From this information, four pooled lots were made up with approximate concentrations (by calculations) of 0.03; 0.05; 0.07 and 0.09 mg lead per 100 ml. of whole blood. All pooled lots were placed in a bottle large enough to accomodate the entire lot. Each pool was filtered through a piece of clean lead-free cheese cloth placed in a 5.5 cm. Buchner funnel in order to remove any coagulated material which may have been introduced in the original blood, in Vacutainers, or which may have formed after pooling of the blood. Very little coagulated material was observed in any of the pools.

Portions of the pool were transferred to a 125 ml. flask (filling flask) from which the blood was drawn into Beckton and Dickenson L3200 Vacutainers (lead-free, 10 ml. capacity) through a 20G 1½" disposable

needle. When the flask became empty, it was refilled by pouring the pooled blood from the bottle containing the pool. Each Vacutainer was given a number so that its contents and place in the sequence of filling would be known. Where the volume of blood in the pool permitted the removal of the required number of Vacutainers of blood as controls, the controls were selected as follows:

a. the first, middle and last Vacutainer drawn from the first filling flask of the pool.

b. the middle vacutainer of the 3rd, 5th, 7th, 9th, etc. filling flask of the pool.

c. the last Vacutainer of blood drawn from the entire pool.

All Vacutainer control samples were analyzed by spectrographic analysis and also by the spectrophotometric dithizone method. The maximum variation found in any one pool was ± 0.005 mg. lead. These analyses indicated that the pools were uniform in lead content and that the Vacutainers of blood supplied the participating laboratories were also uniform in their lead content. Since there was no evidence that the lead content increased or decreased as the Vacutainers were filled from the pools, five Vacutainers of blood were sent by first class mail to each participating laboratory immediately following completion of controls analyses. Two of the Vacutainers sent to each laboratory contained blood from one pool while the remaining three Vacutainers contained blood from each of the other three pools.

Information Supplied to Participating Laboratories

A memo was sent to each participating laboratory on September 30, 1966 advising them that five blood specimens were being shipped to them on this date. It was suggested that these samples be analyzed on October 10, 1966, or if this was not possible that they be analyzed at earliest date after October 10. The memo also stated that the blood samples being shipped were from workers with industrial lead exposures. Oxalated blood had been accumulated and pooled without "spiking" for this study. Since many industrially exposed workers had been treated from time to time with Versenate (EDTA) it was expected that the blood specimens would contain some EDTA. The blood in the Vacutainers should be thoroughly mixed prior to removal for analysis.

Although the participating laboratories were advised that they could use any method of analysis which they desired, it was suggested that they use the method of analysis normally performed in their laboratory.

Each laboratory was assigned an identification number known only to the participating laboratory and the Project Chairman. The specimen number on each Vacutainer was a coded number (each number was vastly different), making it impossible for the participating laboratory to ascertain the specific blood pool represented in each sample. The fact that each laboratory received two Vacutainers of blood from an identical pool was a closely guarded secret

which was not known by any participating laboratory. Because of the coded numbering system used, it was not possible for laboratories to effectively compare their results with other laboratories prior to submitting these to Project Chairman.

Results of Studies

The complete blood-lead results of all the participating laboratories are shown in Table I. The results from laboratories which were reported as milligrams of lead per 100 cc. of whole blood were converted to milligrams of lead per 100 grams of whole blood in order to compare the analytical results. Table II, is a compilation of all results reported in Blood A in numerically ascending order. The final results of 29.2 was deleted for statistical analysis. The mean value reported was 0.039 with a standard deviation of 0.0378.

The results reported on pool blood B are given in Table III. The value of 5.6 listed in the table has been deleted for statistical analysis. The mean value reported for blood B was 0.051 with a standard deviation of 0.0761.

Table IV shows the laboratory results reported for pool blood E. With a value of 5.6 deleted, the mean values reported was 0.086 with a standard deviation of 0.0145.

All the values reported for Blood C & D which are from the same blood pool are listed in Table V. The mean value reported was 0.073. Table VII is a summary of results reported on blood C & D according to the deviation between the results of the two samples reported. Although 23 laboratories reported the same result on each of their two samples,

it is interesting to note that the blood lead concentrations reported varied between 0.000 and 5.6 milligrams of lead per 100 grams of blood. By excluding the two laboratories reporting the greatest variation in the results of their two samples, the difference reported was 0.013 with a standard deviation of 0.020.

Tables VII, VIII and IX indicate the blood lead results reported according to method of preparation, separation and estimation. Table X shows the range of blood lead values reported according to methods of estimation. The average (mean) blood lead results reported according to methods of estimation are given in table XI.

Conclusions

The wide variation in blood-lead levels reported on each pool sample is much greater than can be tolerated. Although each chemist and each laboratory participating in this study believes their results to be accurate, it is obvious that many results reported are unquestionably incorrect. In fact, on the basis of this study, it would appear that some laboratories have no business attempting to perform trace analyses. Of particular interest are the results reported on blood C & D which are samples from one blood pool. Table VI indicates that 23 laboratories found identical lead concentrations in each of their two samples from this same blood pool. Although these laboratories were able to reproduce their results, the lead concentrations reported varied from 0.00 to 5.6 mg. lead per 100 gms. of whole blood. Even if these two extremes and also ridiculous figures are dropped, we still find a lead variation from 0.03 to 0.12.

This study may point up one or more of the following deficiencies:

a) Some laboratories may not be staffed with personnel properly trained and experienced in trace analysis. It was apparent that some laboratory personnel in this study were confused over the terms milligrams and micrograms.

b) Some laboratories may not have or are not utilizing the proper equipment to make blood lead analyses.

c) Some laboratories, although properly equipped and staffed, may not have suitable analytical procedures for these types of analyses.

Most individual laboratories may find it necessary and advantageous to take a good long and hard look at their methods, techniques and standards.

It is a recognized fact that referee or special type of analysis normally get special treatment in most laboratories. It may be interesting to surmise the results of a study of this type were the samples analyzed in each participating laboratory as a routine type sample.

Recommendations

The blood-lead comparison study should be repeated. The blood for another study should be purchased in quantity from donors with industrial exposure to lead rather than making up pools by mixing a large number of individual blood specimens. Only fresh blood should be used on future studies. All laboratories who plan to participate should first study their methods and techniques.

It may be advisable to promote another type of trace analysis referee study in order to ascertain over-all reliability of laboratory competency.

Should future studies indicate that a sizeable number of laboratories do lack competency in trace analysis, it may be necessary that provisions be made by AIHA to furnish referee samples to laboratories routinely so they may periodically check the accuracy of certain types of analyses which they are making. It may also be necessary to give consideration to licensing or granting approval to laboratories for making certain types of analyses.

Acknowledgement

I wish to thank Jack C. Wells, Chief Chemist of my Division for his technical assistance and advice in this study.

FIGURE I.

AIHA BLOOD LEAD STUDY

Laboratory Identification _____
(This is your number)

ANALYTICAL RESULTS

Specimen No.	Lead Content (Use appropriate column)	
	mg Pb/100 cc blood	mg Pb/100 gms blood

Date specimens received _____

ANALYSIS INFORMATION

A. Preparation (check one item)
   1. Digestion (Not taken to a residue) 15
   2. Ashing
      a. Dry 11
      b. Wet 28
   3. Protein Precipitation 4
   4. Blood used without alteration 3

B. Isolation or Separation of Lead (check appropriate items)
   1. Precipitation 1
   2. Extraction
      a. Reagent
         1. Dithizone 37
         2. APDC 5
         3. Other 1
      b. Solvent
         1. Chloroform 36
         2. Carbon Tet 1
         3. MIBK 3
         4. Other 2
   3. No Separation 12

C. Estimation (check one item)
   1. By Color
      a. Visual 2
      b. Colorimeter or Spectrophotometer 37
   2. Titration 1
   3. Polarograph 4
   4. Atomic Absorption 8
   5. Spectrograph
      a. Film 6
      b. Direct Reader 3
   6. Other 0

TABLE I.

COMPLETE BLOOD LEAD RESULTS OF PARTICIPATING LABORATORIES

mg. Lead per 100 gms. Whole Blood

Lab. No.	Blood A	Blood B	Blood C & D		Blood E
1	0.023	0.019	0.028	0.037	0.070
2		.032	.048	.056	.069
3	.066	.076	.056	.062	.078
4	.033	.051	.067	.070	.068
6	.065	.070	.120	.150	.095
7	.042	.060	.067	.087	.102
8	.036	.051	.058	.059	.074
9	.022	.033	.068	.074	.100
10	.070	.058	.084	.103	.122
11	.018	.037	.033	.056	.094
12	.022	.052	.050	.051	.077
14	.027	.048	.062	.062	.077
15	.036	.046	.056	.061	.077
16	.021	.024	.028	.047	.079
18	.050	.041		.071	.034
19	.028	.053	.050	.066	.087
20	.053	.074	.037	.092	.162
21		.130	.115	.120	.030
22	.017	.028	.033	.043	.057
23	.032	.046	.060	.069	.080
24	.051	.062	.060	.066	.078
25	.011	.026		.045	.083
26	.032	.060	.067	.071	.083
27	.010	.012	.028	.031	.034
28	.023		.000	.074	.066
29	.066	.056	.074	.076	.096
30	.017	.047	.036	.048	.070
31	29.2	S.6	S.6	S.6	S.6
32	.054	.063	.068	.077	.087
33	.000	.028	.028	.034	.059
34	.026	.051	.069	.070	.090
36	.036	.050	.071	.075	
38	.030	.052	.062	.064	.079
40	.130	.065	.100	.120	.100
41	.000	.000	.000	.000	.000
43	.023	.051	.063	.066	.085
44	.040			.074	.108
45	.014	.014	.015	.127	.251
46	.032	.048	.061	.072	.068
48	.048	.059	.045	.069	.082
49	.034	.067	.076	.078	.139

Blood Results by Laboratories
Page 2

Lab No.	Blood A	Blood B	Blood C & D		Blood E
50	0.026	0.051	0.059	0.061	0.075
51	.040	.053	.056	.062	.074
52	.035	.055	.067	.067	.086
53	.082	.089	.097	.116	.129
54	.032	.041	.025	.072	.078
55	.048	.066	.050	.060	.102
56	.034	.059	.066	.067	.099
57	.010	.020	.061	.061	.083
58	.036	.046	.050	.060	.069
59	.034	.067	.050	.058	.086
60	.025	.040	.052	.065	.058
61	.040	.052	.061	.067	.074
63	.260	.164	.134	1.05	.172
64	.037	.059	.065	.066	.093
66	.010	.025	.053	.065	.070

TABLE II.

Laboratory Results Reported
mg Lead per 100 gm Whole Blood

Blood A

0.000	0.021	0.030	0.040	0.065
0.000	0.022	0.032	0.040	0.066
	0.022	0.032	0.040	0.066
0.010	0.023	0.032	0.042	
0.010	0.023	0.032	0.045	0.070
0.010	0.023	0.033	0.048	0.082
0.011	0.024	0.034		
0.014	0.026	0.034	0.050	0.130
0.017	0.026	0.034	0.051	0.260
0.017	0.027	0.035	0.053	
0.018	0.028	0.036	0.054	29.2
		0.036		
		0.036		
		0.036		
		0.037		

TABLE III.

Laboratory Results Reported
mg. Lead per 100gms. Whole Blood

Blood B

0.000	0.032	0.050	0.060	0.070
	0.033	0.051	0.060	0.074
0.012	0.037	0.051	0.062	0.076
0.014		0.051	0.063	
0.019	0.040	0.051	0.065	0.089
	0.041	0.051	0.066	
0.020	0.041	0.052	0.067	0.130
0.024	0.046	0.052	0.067	0.164
0.025	0.046	0.052		
0.026	0.046	0.053		3.6
0.028	0.046	0.053		
0.028	0.047	0.055		
	0.048	0.056		
		0.058		
		0.059		
		0.059		
		0.059		

TABLE V.

Laboratory Results Reported

mg. Lead per 100gms. Whole Blood

Blood C & D

0.000	0.043	0.060	0.065	0.070	0.100
0.000	0.045	0.060	0.065	0.070	0.103
0.000	0.047	0.060	0.065	0.071	
	0.048	0.060	0.065	0.071	0.115
0.015	0.048	0.061	0.066	0.071	0.116
		0.061	0.066	0.072	
0.025	0.050	0.061	0.066	0.072	0.120
0.028	0.050	0.061	0.066	0.074	0.120
0.028	0.050	0.061	0.066	0.074	0.120
0.028	0.050	0.061	0.067	0.074	0.127
0.028	0.050	0.061	0.067	0.074	
	0.051	0.062	0.067	0.075	0.134
0.031	0.052	0.062	0.067	0.076	
0.033	0.053	0.062	0.067	0.076	0.150
0.033	0.056	0.062	0.067	0.077	
0.034	0.056	0.063	0.067	0.079	1.05
0.036	0.056	0.064	0.068		
0.037	0.056		0.068	0.084	5.6
0.037	0.056		0.069	0.087	5.6
	0.058		0.069		
	0.058		0.069	0.092	
	0.059			0.097	
	0.059				

TABLE VI.

STATISTICAL ANALYSIS

Laboratory Results on Blood C & D

23 Laboratories Reported Same Results on Each of Their Two Samples, With The Following Concentrations Reported:

Number of Laboratories	Lead Concentration
1	0.00
2	0.03
1	0.05
8	0.06
8	0.07
1	0.08
1	0.12
1	5.6

15 Laboratories Reported Results On Each Of Their Two Samples Which Varied By Only 0.01 mg., With The Following Concentrations Reported:

Number of Laboratories	Lead Concentration
2	0.03-0.04
1	0.04-0.05
4	0.05-0.06
5	0.06-0.07
3	0.07-0.08

8 Laboratories Reported Results on Each of Their Two Samples which varied by only 0.02 mg., With The Following Concentrations Reported:

Number of Laboratories	Lead Concentration
1	0.03-0.05
3	0.05-0.07
1	0.07-0.09
1	0.08-0.10
2	0.10-0.12

7 Laboratories Reported Results on Each of Their Two Samples which varied by 0.03 mg. or More, With The Following Concentrations Reported:

Number of Laboratories	Lead Concentration
1	0.00-0.07
1	0.07-0.13
1	0.01-0.04
1	0.03-0.07
1	0.04-0.09
1	0.12-0.15
1	0.13-1.05

TABLE VII.

BLOOD LEAD RESULTS REPORTED ACCORDING TO METHOD OF PREPARATION

Digestion;	Extraction with dithizone; Solvent - chloroform. Estimation by Visual Color			
	29.2	5.6	5.6 - 5.6	5.6
Digestion;	Extraction with dithizone; Solvent - chloroform. Estimation by Color - Spectrophotometer			
	.033	.051	.067-.070	.068
	.036	.046	.056-.061	.077
	---	.130	.115-.120	.050
	.030	.052	.062-.064	.079
	.040	---	--- .074	.108
	.034	.067	.076-.079	.139
	.040	.052	.061-.067	.074
Range	.030-.040	.046-.130	.056-.120	.030-.139
Average	.036	.066	.074	.082
Digestion;	Extraction with dithizone; Solvent - chloroform. Estimation by Titration			
	.000	.000	.000-.000	.000
Digestion;	Extraction with APDC; Solvent - MIBK. Estimation by Atomic Absorption			
	.011	.026	--- .045	.083
Digestion;	No Separation of Lead. Estimation by Spectrochemical - Film			
	.066	.076	.056-.062	.078
	.054	.063	.068-.077	.087
Digestion;	No Separation of Lead. Estimation by Spectrochemical - Direct Reader			
	.036	.051	.058-.059	.074
Dry Ashing;	Extraction with dithizone; Solvent - chloroform. Estimation by Color - Spectrophotometer			
	---	.032	.048-.056	.069
	.027	.048	.062-.062	.077
	.051	.062	.060-.066	.078
	.017	.047	.036-.048	.070
	.040	.053	.056-.062	.074
	.034	.067	.050-.058	.086
Range	.017-.051	.032-.067	.036-.066	.069-.086
Average	.034	.052	.056	.076

Dry Ashing; Extraction with dithizone; No Solvent Listed.
Estimation by Polarograph

.032	.041	.025-.072	.078

Dry Ashing; No Separation of Lead.
Estimation by Polarograph

.050	.041	-- -.071	.034

Dry Ashing; No Separation of Lead.
Estimation by Spectrochemical - Film

.065	.070	.120-.150	.095
.130	.065	.100-.120	.100

Wet Ashing; Extraction with Dithizone; Solvent - Chloroform.
Estimation by Visual Color.

.037	.059	.065-.066	.093

Wet Ashing; Extraction with Dithizone; Solvent - Chloroform.
Estimation by Color - Spectrophotometer

.021	.024	.028-.047	.079
.028	.053	.050-.066	.087
.053	.074	.037-.092	.162
.017	.028	.033-.043	.057
.032	.046	.060-.069	.080
.032	.060	.067-.071	.083
.010	.012	.028-.031	.034
.023	---	.000-.074	.066
.066	.056	.074-.076	.096
.026	.051	.069-.070	.090
.036	.050	.071-.075	---
.023	.051	.063-.066	.085
.045	.059	.065-.069	.082
.026	.051	.059-.061	.075
.048	.064	.050-.060	.102
.034	.059	.066-.067	.099
.040	.052	.061-.067	.074
Range .010-.066	.012-.074	.000-.092	.034-.162
Average .033	.050	.058	.084

Wet Ashing; Extraction with Dithizone; Solvent - Chloroform.
Estimation by Polarograph

.000	.028	.028-.034	.059

Wet Ashing; Extraction with Dithizone; Solvent - Carbon Tetrachloride
Estimation by Color - Spectrophotometer

.042	.069	.097-.116	.129

Wet Ashing; Extraction with APDC; Solvent - Chloroform
Estimation by Atomic Absorption

.035	.055	.067-.067	.086

Wet Ashing; Extraction with APDC Solvent - MIBK
Estimation by Atomic Absorption

.036	.046	.050-.060	.069

Wet Ashing; No Extraction Reagent Listed; Solvent - Other
Estimation by Atomic Absorption

.070	.058	.084-.103	.122

Wet Ashing; No Separation of Lead
Estimation by Atomic Absorption

.042	.060	.067-.087	.102

Wet Ashing; No Separation of Lead
Estimation by Polarograph

.014	.014	.015-.127	.251

Wet Ashing; No Separation of Lead
Estimation by Spectrochemical - Film

.022	.052	.050-.051	.077

Protein Precipitation; Extraction with APDC; Solvent - MIBK
Estimation by Atomic Absorption

.023	.019	.028-.037	.070
.022	.033	.068-.074	.100

Protein Precipitation; No Separation of Lead.
Estimation by Spectrochemical - Direct Reader

.010	.020	.061-.061	.083
.010	.025	.053-.065	.070

Blood Used Without Alteration; Precipitation of Lead; Other Reagent.
Estimation by Atomic Absorption

.023	.019	.028-.037	.070

Blood Used Without Alteration; No Separation of Lead
Estimation by Spectrochemical - Film

.032	.046	.061-.072	.068

TABLE VIII.

BLOOD LEAD RESULTS REPORTED
ACCORDING TO METHOD OF SEPARATION

Precipitation; Blood Used Without Alteration; Solvent - Other
Estimation by Atomic Absorption

.018	.037	.033-.056	.084

Extraction with Dithizone; Solvent - Chloroform; Preparation-Digestion
Estimation by Visual Color

29.2	5.6	5.6-5.6	5.6

Extraction with Dithizone; Solvent - Chloroform; Preparation-Digestion
Estimation by Color - Spectrophotometer

	.033	.051	.067-.070	.068
	.036	.046	.056-.061	.077
	---	.130	.115-.120	.030
	.030	.052	.062-.064	.079
	.040	---	-- -.074	.108
	.034	.067	.076-.079	.139
	.025	.040	.052-.065	.058
Range	.025-.040	.040-.130	.052-.120	.030-.139
Average	.033	.064	.074	.080

Extraction with Dithizone; Solvent-Chloroform; Preparation - Digestion

.000	.000	.000-.000	.000

Extraction with Dithizone; Solvent-Chloroform; Preparation - Dry Ashing
Estimation by Color - Spectrophotometer

	---	.032	.048-.056	.069
	.027	.048	.062-.062	.077
	.051	.062	.060-.066	.078
	.017	.047	.036-.048	.070
	.040	.053	.056-.062	.074
	.034	.067	.050-.058	.086
Range	.017-.051	.032-.067	.036-.066	.069-.086
Average	.034	.052	.056	.076

Extraction with Dithizone; Solvent-Chloroform; Preparation - Wet Ashing
Estimation by Visual Color

.037	.059	.063-.066	.093

Extraction with Dithizone; Solvent-Chloroform; Preparation - Wet Ashing
Estimation by Color - Spectrophotometer

	.021	.024	.028-.047	.079
	.028	.053	.050-.066	.087
	.053	.074	.037-.092	.162
	.017	.028	.033-.043	.057
	.032	.046	.060-.069	.080
	.032	.060	.067-.071	.083
	.010	.012	.028-.031	.034
	.023	--	.000-.074	.066
	.066	.056	.074-.076	.096
	.026	.051	.069-.070	.090
	.036	.050	.071-.075	--
	.023	.051	.063-.066	.085
	.045	.059	.065-.069	.082
	.026	.051	.059-.061	.075
	.048	.066	.050-.060	.102
	.034	.059	.066-.067	.099
	.040	.052	.061-.067	.074
Range	.010-.066	.012-.074	.000-.092	.034-.162
Average	.033	.050	.058	.078

Extraction with Dithizone; Solvent-Chloroform; Preparation - Wet Ashing
Estimation by Polarograph

	.000	.028	.028-.034	.059

Extraction with Dithizone; Solvent - Carbon Tetrachloride; Preparation - Wet Ashing
Estimation by Color - Spectrophotometer

	.082	.089	.097-.116	.129

Extraction with Dithizone; No Solvent Listed; Preparation - Dry Ashing
Estimation by Polarograph

	.032	.041	.025-.072	.078

Extraction with APDC; Solvent - Chloroform; Preparation - Wet Ashing
Estimation by Atomic Absorption

	.035	.055	.067-.067	.086

Extraction with APDC; Solvent - MIBK; Preparation - Wet Ashing
Estimation by Atomic Absorption

	.036	.046	.050-.060	.049

Extraction with APDC; Solvent - MIBK; Preparation - Protein Precipitation
Estimation by Atomic Absorption

	.023	.019	.028-.037	.070
	.022	.033	.068-.074	.100

No Separation; Preparation - Wet Ashing
Estimation by Atomic Absorption

.070	.058	.084-.103	.122

No Separation; Preparation - Digestion
Estimation by Spectrochemical - Film

.066	.076	.056-.062	.078
.054	.063	.068-.077	.087

No Separation; Preparation - Digestion
Estimation by Spectrochemical - Direct Reader

.036	.051	.058-.059	.074

No Separation; Preparation - Dry Ashing
Estimation by Polarograph

.050	.041	-- -.071	.034

No Separation; Preparation-Dry Ashing
Estimation by Spectrochemical - Film

.065	.070	.120-.150	.095
.130	.065	.100-.120	.100

No Separation; Preparation - Wet Ashing
Estimation by Atomic Absorption

.042	.060	.067-.087	.102
.070	.058	.084-.103	.122

No Separation; Preparation - Wet Ashing
Estimation by Spectrochemical - Film

.022	.052	.050-.051	.077

No Separation; Preparation - Protein Precipitation
Estimation by Spectrochemical - Direct Reader

.010	.020	.061-.061	.083
.010	.025	.053-.065	.070

No Separation; Preparation - Blood Used Without Alteration
Estimation by Spectrochemical - Film

.032	.046	.061-.072	.068

TABLE IX.

BLOOD LEAD RESULTS REPORTED ACCORDING TO METHOD OF ESTIMATION

Visual Color;	Preparation - Digestion By Dithizone - Chloroform Extraction			
	29.2	5.6	5.6-5.6	5.6
Visual Color;	Preparation - Wet Ashing By Dithizone - Chloroform Extraction			
	.037	.059	.065-.066	.093
Color - Spectrophotometer;	Preparation - Digestion By Dithizone - Chloroform Extraction			
	.033	.051	.067-.070	.068
	.036	.046	.056-.061	.077
	--	.130	.115-.120	.030
	.030	.052	.062-.064	.079
	.040	--	-- -.074	.108
	.034	.067	.076-.079	.139
	.025	.040	.052-.065	.058
Range	.025-.040	.040-.130	.052-.120	.030-.139
Average	.033	.064	.074	.080

Color-Spectrophotometer; Preparation - Dry Ashing
By Dithizone - Chloroform Extraction

	--	.032	.048-.056	.069
	.027	.048	.062-.062	.077
	.051	.062	.060-.066	.078
	.017	.047	.036-.048	.070
	.040	.053	.056-.062	.074
	.034	.067	.050-.058	.086
Range	.017-.051	.032-.067	.036-.066	.069-.086
	.034	.052	.056	.076

Color-Spectrophotometer; Preparation - Wet Ashing
By Dithizone - Chloroform Extraction

	.021	.024	.028-.047	.079
	.028	.053	.050-.066	.087
	.055	.074	.037-.092	.162
	.017	.028	.033-.043	.057
	.032	.046	.060-.069	.080
	.032	.060	.067-.071	.083
	.010	.012	.028-.031	.034
	.023	--	.000-.074	.066
	.066	.056	.074-.076	.096
	.026	.051	.069-.070	.090
	.036	.050	.071-.075	--
	.023	.051	.063-.066	.085
	.045	.059	.065-.069	.082
	.026	.051	.059-.061	.075
	.048	.066	.050-.060	.102
	.034	.059	.066-.067	.099
	.040	.052	.061-.067	.074
	.260	.164	.134-1.05	.172
Range	.010-.260	.012-.164	.000-1.05	.034-.172
Average	.046	.056	.088	.090
		By deleting last row of results above		
Range	.010-.066	.012-.074	.000-.092	.034-.162
Average	.033	.050	.058	.084

Color-Spectrophotometer; Preparation - Wet Ashing
By Dithizone - Carbon Tetrachloride Extraction

.082	.089	.097-.116	.129	

Titration; Preparation - Digestion
By Dithizone - Chloroform Extraction

.000	.000	.000-.000	.000

Polarograph; Preparation - Dry Ashing
By Dithizone Extraction - No Solvent Listed

.032	.041	.025-.072	.078

Polarograph; Preparation - Dry Ashing
No Lead Separation.

.050	.041	-- -.071	.034

Polarograph; Preparation - Wet Ashing
By Dithizone - Chloroform Extraction

.000	.028	.028-.034	.059

Polarograph; Preparation - Wet Ashing
No Lead Separation

.014	.014	.015-.127	.251

Atomic Absorption; Preparation - Digestion
By APDC - MIBK Extraction

.011	.026	-- -.045	.083

Atomic Absorption; Preparation - Wet Ashing
By APDC - Chloroform Extraction

.035	.055	.067-.067	.046

Atomic Absorption; Preparation - Wet Ashing
By APDC - MIBK Extraction

.036	.046	.050-.060	.069

Atomic Absorption; Preparation - Wet Ashing
By Other Solvent Extraction

.070	.058	.084-.103	.122

Atomic Absorption; Preparation - Wet Ashing
No Lead Separation

.042	.060	.067-.087	.102

Atomic Absorption; Preparation - Protein Precipitation
By APDC - MIBK Extraction

.023	.019	.028-.037	.070
.022	.033	.068-.074	.100

Atomic Absorption; Blood Used Without Alteration
Precipitation of Lead

.018	.037	.033-.056	.094

Spectrochemical - Film (Plate); Preparation - Digestion
No Separation of Lead

.066	.074	.056-.062	.078
.054	.063	.068-.077	.087

Spectrochemical - Film (Plate); Preparation - Dry Ashing
No Separation of Lead

.065	.070	.120-.150	.095
.130	.065	.100-.120	.100

Spectrochemical - Film (Plate); Preparation - Wet Ashing
No Separation of Lead

.022	.052	.050-.051	.077

Spectrochemical - Film (Plate); Blood Used Without Alteration
No Separation of Lead

.032	.046	.061-.072	.068

Spectrochemical - Director Reader; Preparation - Digestion
No Separation of Lead

.036	.051	.058-.059	.074

Spectrochemical - Direct Reader; Preparation - Protein Precipitation
No Separation of Lead

.010	.020	.061-.061	.083
.010	.025	.053-.065	.070

TABLE X

RANGE OF BLOOD LEAD RESULTS REPORTED ACCORDING TO METHODS OF ESTIMATION

Method	Blood A	Blood B	Blood C & D	Blood E
Spectrophotometer	010-260	012-164	000-1.05	034-172
" (Delete one Lab)	010-032	012-089	000-116	034-129
Polarograph	000-050	014-041	015-127	034-251
Atomic Absorption	011-070	019-060	028-103	069-122
Spectrochemical - Film	022-130	046-074	050-150	068-100
" - Direct Reader	010-036	020-051	053-065	070-083

TABLE XI.

AVERAGE (MEAN) BLOOD LEAD RESULTS REPORTED ACCORDING TO METHODS OF ESTIMATION

	Blood A	Blood B	Blood C & D	Blood E
Spectrophotometer	055	054	063	082
Polarograph	024	031	053	106
Atomic Absorption	032	042	061	091
Spectrochemical - Film	069	062	082	084
" - Direct Reader	019	032	060	076