Blood Lead Determinations as a Health Department Laboratory Service*

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THE Baltimore City Health Department first became interested in lead poisoning in 1929 in an investigation of several cases of industrial lead poisoning. This interest was broadened in 1932 when an outbreak of 40 non-fatal cases of lead poisoning occurred mostly in children as a result of the inhalation of fumes and dust arising from the use of discarded storage battery casings for fuel.[1] Subsequently, for a period of more than four years all cases of lead poisoning which came to the attention of the Health Department were routinely investigated in order to ascertain if possible the source of the lead exposure in both adults and children. Early in 1935, at the request of Dr. Edwards A. Park, Pediatrician-in-Chief at the Johns Hopkins Hospital, the Bureau of Laboratories provided facilities for the quantitative estimation of lead in blood in cases of suspected plumbism. These facilities were soon expanded into a routine service. The usefulness of the quantitative blood lead analysis as an index of abnormal lead absorption had already been demonstrated at that time by the extensive studies of Blumberg and Scott at the Johns Hopkins Hospital[2] as well as by other investigators.[3, 4] Subsequent investigations have further confirmed the value of this analysis in providing evidence of lead absorption in cases of suspected lead intoxication.[5-14]

Since July, 1935, we have routinely examined more than 1,400 specimens of blood from over 1,000 individuals. The blood lead service has been used by more than 20 local hospitals and by more than 80 private physicians. At the present time approximately 30 specimens of blood are examined each month. No charge is made for this work. It is the purpose of the present report to describe this unique laboratory service and to call attention to the valuable assistance which it has given to our Division of Industrial Hygiene and Bureau of Occupational Diseases in locating lead hazards and in evaluating the extent of lead poisoning in the community.

COLLECTION OF SPECIMENS

Ten gram samples of whole clotted blood are used in these examinations. In order to minimize contamination, only specimens submitted in prepared containers known as "blood lead outfits" (Figure 1) are accepted for analysis. The outfit consists of a lead-free glass test tube (17 mm. x 91 mm.) stoppered with a clean new XXXX quality Armstrong cork. The tube is first cleaned, then rinsed with nitric acid and lead-free water, and dried. The tube, together with an identification card requesting information concerning the

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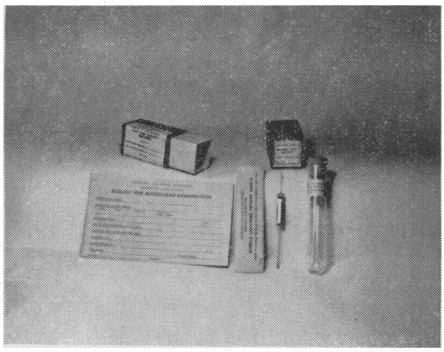

FIGURE 1

name, address, age, sex, color, occupation, and length of exposure to lead of the patient is packed in a distinctive cardboard box bearing the " blood lead outfit " label. Directions for collecting the blood specimen are printed on the reverse side of the card. Recently, the outfit was further improved by the provision of a sterile, lead-free, rustless, 19 gauge, Petroff needle (Becton Dickinson, Number 497N) contained in a small paper envelope. The needle is suitable for adult use only and eliminates the need for a syringe. The cost to us of the blood lead outfit including the needle is 7½ cents. The outfits are distributed by the Bureau of Laboratories to the local medical profession and hospitals in the same manner as outfits regularly provided for the collection of specimens in cases of infectious diseases.

METHOD OF ANALYSIS

It is now well established that traces of lead are normally present in the blood. The difference between normal and abnormal amounts of lead in circulating blood is a quantitative and not a qualitative distinction and requires the use of highly sensitive and accurate means of lead estimation. In this work the modification of the dithizone method described by Wilkins, Willoughby, *et al.*[5, 15] was used. The method was further modified to include the neutral wedge photometer in accordance with the technic of Clifford and Wichmann.[16]

Meticulous supervision is required. The method is practical only when a sufficient volume of samples is anticipated. In our laboratory, reagents and equipment are available for the simultaneous examination of 6 specimens. This equipment necessitated an outlay over a period of 4 years of more than $400. However, the average cost of a single examination is estimated at about 25 cents. The figure given does not include the cost of labor. When analyses are made in multiple, the average time required of the analyst for a single analysis is slightly more than 1 hour.

REPORTING OF RESULTS

Blood lead concentrations are reported as mg. lead per 100 gm. of blood. Recently, for convenience, the following summary of the interpretation of the blood lead value was printed on the report form which is mailed to the physician.

INTERPRETATION OF RESULTS

It is now recognized that in the general population the average lead content of the blood is about 0.03 mg. per 100 gm. In persons with no history of exposure to lead, the blood lead level may range as high as 0.05 to 0.06 mg. per 100 gm. of blood. Higher blood lead values are evidence of abnormal absorption of lead and suggest the relative severity of the recent lead exposure.

Lead absorption is not synonymous with lead poisoning. Experience has demonstrated that individuals in industrial lead exposures may have abnormal blood lead levels with no accompanying symptomatology. A high blood lead level is not, of itself, diagnostic of lead poisoning but must be correlated with other findings, both clinical and laboratory, as well as with a history of definite exposure to lead.

No direct correlation exists between the degree of elevation of the blood lead value and the severity of the symptoms. It should be further noted that in convalescence from lead poisoning the blood lead value may remain in the abnormal range for a considerable period after symptoms have disappeared.

TABLE 1

Initial Blood Lead Values in Normal Individuals and in Cases of Suspected Lead Poisoning

Mg. Lead per 100 gm. Blood	Normal Controls	Suspected Lead Poisoning: Positive Clinical Diagnosis: Adults	Suspected Lead Poisoning: Positive Clinical Diagnosis: Children	Suspected Lead Poisoning: Negative Clinical Diagnosis: Adults	Suspected Lead Poisoning: Negative Clinical Diagnosis: Children
0.00	2	..	..	1	..
0.01	8	..	..	10	9
0.02	25	..	..	31	17
0.03	41	..	..	68	40
0.04	39	..	..	79	50
0.05	8	1	..	57	22
0.06	1	6	..	23	19
0.07	1	3	..	8	13
0.08	1	8	1	6	7
0.09	..	9	6	2	..
0.10–0.20	..	46	26	5	..
0.21–0.30	..	3	22	1	..
0.31–0.40	..	5	7	..	..
0.41–0.50	..	..	8	..	..
0.51–0.60	..	1	3	..	..
0.61–0.70	..	..	1	..	..
TOTAL (750)	126*	82	74	291	177

* Mean normal value 0.031 with standard deviation ±0.012.

If the findings in this report indicate a doubtful result or an abnormal absorption of lead, an additional specimen of blood and also a specimen of urine should be examined. Because of the time and expense involved in making these analyses, physicians must communicate directly with the Director, Bureau of Laboratories, in order to make arrangements for repeat tests.

This interpretation is based on the available literature cited in the above references as well as upon our own experience.

SUMMARY OF BLOOD LEAD FINDINGS

At the outset the laboratory service was intended merely to provide practitioners with an aid in the diagnosis of lead poisoning particularly in cases involving infants and young children. The coöperation of the hospitals and private physicians who made use of the laboratory service was solicited in order to make available the clinical histories of those individuals whose bloods had been examined for lead. This investigative work was expanded after the creation of the Bureau of Occupational Diseases in the Baltimore City Health Department in 1936. In this way, an excellent source of information was provided as to the occurrence of both industrial and nonindustrial lead poisoning in the city. In addition a study of the case histories permitted a correlation of the chemical blood lead determination with the clinical signs and symptoms, the history of exposure, and the final diagnosis made in each instance. Case histories of 624 individuals (373 adults and 251 children) have thus far been examined. A distribution of the blood lead values of this group in relation to the clinical diagnoses made is shown in Table 1.

Initial blood lead values only are recorded in this table; values obtained in convalescence or after treatment are not shown. The table also includes a series of specimens from 31 adults and 95 children (126 in all) with no history

of industrial or other exposure to lead. These specimens were obtained through the coöperation of the local infectious disease hospital. The blood lead values in this "normal" group were not significantly different for the adults and children. Since these individuals were not "normal" with respect to health, it is conceivable that metabolic disturbances associated with infectious disease may have slightly elevated the blood lead values of some members of the series.

In the group diagnosed as clinical lead poisoning our data include 82 adults, all but one of whom contracted lead poisoning in the course of their occupations; and 74 children of an average age of 2½ years, practically all of whom had a history of pica associated with the chewing of objects painted with lead containing paints. In many of the children's cases, analyses were made of paint scrapings to confirm the source of lead. Specimens from all but one of the 251 children were submitted from hospitals. On the other hand, specimens from 30 per cent of the adults were submitted by private physicians.

In plumbism, the most commonly occurring blood lead values in both adults and children was in the range of 0.1 to 0.2 mg. per 100 gm. of blood. Values in excess of 0.2 mg. occurred far more frequently in affected children than in adults.

The group tabulated as "negative clinical diagnosis" consists of individuals whose clinical histories did not show a diagnosis of lead poisoning. Many of the children in this group had a history of pica. Almost all of the adults were engaged in occupations wherein some abnormal absorption of lead might be suspected. Those adults in this category who showed blood lead values in excess of 0.07 mg. were definite examples of asymptomatic lead absorption. These men were engaged in such occupations as the manufacture of lead paint pigments, the manufacture of lead arsenate, scrap lead reclamation, and lead burning.

USEFULNESS OF THE BLOOD LEAD SERVICE AS A HEALTH DEPARTMENT METHOD

The local medical profession is accustomed to asking for a blood lead determination by the Baltimore City Health Department in cases of suspected lead poisoning encountered in their practice. A copy of the result of each analysis is forwarded to the Bureau of Occupational Diseases for investigation. In this way the majority of the actual lead hazards in local industry have been defined and numerous corrections of lead exposures were obtained.

With the reports from the blood lead service as a clue, numerous instances have occurred in the past 6 years wherein outbreaks of industrial lead poisoning were immediately called to the attention of the Bureau of Occupational Diseases and the Division of Industrial Hygiene. An excellent example which has already been cited [17] related to an incident involving several cases of lead poisoning in a manufacturing plant. A cross-connection in plumbing permitted a solution of lead compound to enter the water supply of a drinking fountain in the plant. Numerous other incidents have occurred which involve such diverse occupations as the manufacture of lead arsenate, the manufacture of lead paint pigments, acetylene torch burning in shipbreaking, enamelling with lead-containing frit and the cleaning of tanks which had been used for the storage of leaded gasoline.

In recent years, largely as a result of studies associated with a follow-up of the blood lead laboratory service, it has been possible for the Baltimore City Health Department to acquire relatively accurate information concern-

TABLE 2

Reporting of Non-fatal Lead Poisoning in Baltimore City, 1931–1940

Year	Total Non-Fatal Cases	Cases Reported		Cases Not Reported But Ascertained Through Follow-up of Laboratory Service	
		Adult	Child	Adult	Child
1931	..	..	..	..	..
1932	49	12	37	..	..
1933	2	2	..	..	..
1934	4	..	4	..	..
1935	12	1	4	4	3
1936	26	3	..	12	11
1937	24	..	..	16	8
1938	11	2	..	2	7
1939	18	..	..	11	7
1940	26	3	..	18	5
TOTAL	172	23	45	63	41

ing the incidence of lead poisoning in the community.[18] During the past 10 years, all of the known cases of fatal lead poisoning (49 children and 7 adults) were reported to the Bureau of Vital Statistics. However, there has been little tendency to report cases of non-fatal lead poisoning. This fact is strikingly demonstrated in Table 2.

The increased incidence of reported lead poisoning in 1932 is due to the storage battery outbreak mentioned earlier.[1] Beginning in 1935, it will be noted that the Health Department became aware of a large number of unreported cases of non-fatal lead poisoning. This resulted directly from the follow-up of the laboratory service. Only those cases are listed in which an investigation with regard to the history of exposure, signs, symptoms, and laboratory examination furnished evidence to substantiate the diagnosis of lead poisoning.

SUMMARY

A description has been given of a blood lead laboratory service which the Bureau of Laboratories of the Baltimore City Health Department has made available to the physicians and hospitals of Baltimore during the past 6 years. The service has proved invaluable to the Division of Industrial Hygiene and the Bureau of Occupational Diseases in locating lead hazards and in evaluating the extent of both industrial and nonindustrial lead poisoning in the community.

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