# Difficulties in Evaluating Abnormal Lead Screening Results in Children

*Bruce Block, MD, Keith Szekely, MD, and Milagro Escobar, MD*

***Background:*** **This report chronicles efforts to provide follow-up care for children with abnormal whole blood lead concentrations using the 1991 Centers for Disease Control and Prevention (CDC) guidelines in the Family Health Center at Shadyside Hospital in Pittsburgh.**

***Methods:*** **An automated surveillance module found all children with abnormal lead concentrations obtained between January 1994 and July 1995 and singled out children who were overdue for follow-up. Automated physician reminders and nursing case management were used to improve care and documentation. Longitudinal case summaries were used to evaluate care.**

***Results:*** **All 99 children with a lead concentration of 10 µg/dL or greater had a documented follow-up plan. Twenty-nine children (47 percent) who had a lead concentration of 10 to 14 µg/dL, 23 (100 percent) who had a lead concentration of 15 to 19 µg/dL, and 8 (100 percent) who had a lead concentration of 20 µg/dL or greater had at least one follow-up lead concentration measurement by the end of the data collection in July 1995. Follow-up was incomplete in more than 70 percent of children. Nineteen children (19 percent) with initially abnormal lead concentrations had follow-up testing with persistently normal results. The yearly cost of follow-up was $15,888, with only 7 children requiring county health environmental intervention.**

***Conclusions:*** **The nurse-centered, computer-aided system improved follow-up care of children with abnormal lead concentrations, but most patients still did not receive mandated follow-up testing because of logistic obstacles. The effort and cost associated with CDC-mandated follow-up of children with lead concentrations between 10 and 19 µg/dL provides no apparent benefit and might detract from the care of children at higher risk. (J Am Board Fam Pract 1996;9:405-10.)**

Numerous reports attest to the likelihood of finding small elevations of whole blood lead concentrations when screening young children, but no reports address the problems of abnormal test result follow-up. Urban practices with large indigent populations often report elevated blood lead concentrations (≥ 10 µg/dL) in more than 15 percent of children.[1-3] Suburban practices tend to find elevations in less than 6 percent of children.[3-5] Obtaining these capillary blood-screening values is not difficult because samples are collected at the same time as hemoglobin testing during well-child visits. Following up abnormal results, however, consumes a great deal of office staff time. This report chronicles efforts to accomplish effective follow-up of children with abnormal lead concentrations in the Family Health Center at Shadyside Hospital.

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From the Primary Care Institute, Shadyside Hospital, Pittsburgh (BB, KS, ME). Address reprint requests to Bruce Block, MD, 5215 Centre Ave, Pittsburgh, PA 15232.

The Family Health Center is the clinical practice for the 10 faculty and 27 residents of the Family Practice Residency Program located in the East End of Pittsburgh. The center receives more than 20,000 patient visits a year, each of which is documented in a computerized medical record system. About one third of the patients are younger than 15 years old, more than one half of the children are African-American, and more than two thirds are on medical assistance.

## Methods

The Family Health Center began screening children for lead poisoning after enrolling in Pennsylvania's Early Prevention, Screening, Detection, and Treatment program in 1987, and has continued to modify record-keeping and follow-up methods since then. Initially age-specific well-child care work sheets were developed that included prompts to physicians to order lead concentration measurements at the state-mandated ages. When the Centers for Disease Control and Prevention (CDC) published guidelines

**Table 1. Shadyside Family Health Center Lead-Screening Guidelines.**

1. Capillary lead concentration reviewed by nursing staff
2. Lead concentration entered into log book
3. If lead is ≥ 10 µg/dL, protocol recommendation highlighted, attached to result report by nurse, and given to physician

**Protocol**

***6 to 36 months***

Screen as per well-child care work sheet

If test <10 µg/dL, recheck as per prompt on well-child care work sheet

If test 10-14 µg/dL, recheck in 3 months

If two tests <10 µg/dL or three tests <15 µg/dL, retest as on well-child care work sheet

If test ≥ 15 µg/dL, obtain venous sample as per Table 6-4 in CDC manual

If any venous test ≥ 15 µg/dL, see case management protocol below

***36 to 72 months***

Screen as per well-child care work sheet

If test <15 µg/dL, recheck as per well-child care work sheet

If test ≥ 15 µg/dL, obtain venous sample as per Table 6-4 in CDC manual

If any venous test ≥ 15 µg/dL see case management protocol below

**Case management**

If venous test 15-19 µg/dL: education, nutrition, environmental history, and retest in 3 months

If two venous tests < 10 µg/dL or three tests < 15 µg/dL, retest as on well-child care work sheet

If venous test 15-19 µg/dL on two consecutive tests, refer to county health department for environmental investigation and abatement

If venous test 20-44 µg/dL, appropriate history and physical examination, ferritin or trial of iron, protoporphyrin level, and environmental intervention

If venous test ≥ 45 µg/dL, referral for further evaluation and chelation therapy is indicated

**Follow-up problems**

If patient misses follow-up visit, then a taxicab pass should be offered. If that doesn't work, ask nurse with Maternal and Child Health to see whether they can go to the home or assure that the patient will come in. If this is not feasible, contact county health department for help.

for screening and intervention in 1991,[6] the lead-screening program was expanded to include testing all children seen at 12, 18, 24, 36, 48, and 60 months of age. In the first year of the new screening program, the Family Health Center performed a limited chart review of 22 children who had abnormal whole blood lead concentrations between May and December of 1992. The review showed that documentation and follow-up were poor. Only 7 children (32 percent) had a follow-up plan documented in the chart. Only 2 children had follow-up tests done, and 1 child was referred to the county health department.

In response to these findings, a protocol for selection and follow-up of children with abnormal values was developed (Table 1). Under this plan, lead-testing results were routed to an office nurse who reviewed them based on the screening guidelines. Abnormal screening results were passed along to physicians with a copy of the guidelines, highlighted to indicate recommended responses. The nurse also noted the test result and recommendation in a log book. The physician could authorize an alternative follow-up plan; otherwise, the nurse took responsibility for assuring compliance with the CDC recommendation.

Periodically the nurse reviewed the log book to assess the progress of each case. This proved to be so time-consuming that the nurse could not keep up with the task. In late 1993 the Family Health Center started using its automated medical record system health surveillance module[7] to monitor patient progress. Physician reminders, generated by the computer module, were attached to the chart at the time of the patient visit. The module also created administrative reports of patients who were overdue for lead screening (Figure 1).

Evaluation of the effectiveness of the revised lead-screening and follow-up system was made by studying the charts of all children with abnormal lead concentrations discovered between January 1994 and July 1995. Two first-year residents reviewed the automated problem lists and progress notes, entries in the nursing log books, and relevant letters, messages, and laboratory results in the charts. Longitudinal case summaries were constructed for each patient to evaluate care and to determine which children were overdue for follow-up of abnormal lead concentrations.

## Results

### *Prevalence*

Of the 1001 lead measurements obtained between January 1994 and July 1995, 234 tests on 99 children resulted in concentrations of 10 µg/dL or greater. During the 18-month study period, the office performed an average of 2.5 tests per day. All but 17 of the lead measurements were obtained on capillary blood samples.

The distribution of abnormal initial lead levels is shown in Table 2.

**Table 2. Distribution of Initially Abnormal Blood Lead Results.**

| Initial Lead Level | Number of Children | Percent of Abnormal Results |
|---|---|---|
| 10-14 μg/dL | 67 | 68 |
| 15-19 μg/dL | 24 | 24 |
| 20-44 μg/dL | 8 | 8 |
| 45-69 μg/dL | 0 | 0 |

### *Follow-up of Abnormal Levels*

All 99 children who had abnormal capillary lead concentrations between January 1994 and July 1995 had a follow-up plan recorded in the automated medical record. As of July 1995, 19 (19 percent) of the 99 children with initially abnormal lead concentrations had follow-up testing that showed persistently normal levels. Eighty children remained in the abnormal lead concentration category because they failed to complete the requisite number of normal follow-up tests. Seventy-one of these children were at least 1 month overdue for their next lead measurement, whereas only 9 were not overdue. Two hundred thirty-seven lead measurements were done on the 99 children who had abnormal lead concentrations, for an average of 2.4 tests per child.

### *Sequential Lead Test Results*

Ninety-three patients with abnormal concentrations were supposed to receive a follow-up lead measurement prior to the end of the study period. Sixty of these children (65 percent) had at least one follow-up lead measurement performed. Twenty-nine of 62 children (47 percent) who had a lead concentration of 10 to 14 μg/dL, 23 of 23 children (100 percent) who had a lead concentration of 15 to 19 μg/dL, and 8 of 8 children (100 percent) who had a lead concentration of 20 μg/dL or greater had at least one follow-up blood lead measurement by the end of the data collection in July 1995.

Four of 29 children with initial capillary lead concentrations of 10 to 14 μg/dL developed lead concentrations of 20 μg/dL or greater on repeat testing, but only two measurements were confirmed by venous sampling. When venous lead samples were obtained from patients with initial capillary values of 15 μg/dL or greater, they increased in only 3 of 15 cases (20 percent). In fact, 8 of 15 children with screening capillary concentrations of 15 μg/dL or greater had normal venous lead concentrations on retesting.

### *Limitations of the Tracking System*

Three children should not have been in the system at all because their samples were insufficient, not abnormal. Nineteen children whose lead concentrations became normal with subsequent testing were still coded as abnormal in the computer tracking system. In all, 22 of the 99 (22 percent) children were incorrectly coded in the system by

CASSWELL, ROLANDO 4 yrs DOB 17-Sep-90 Pt# 78273 BRISCOE, DONALD, MD Ch# 78273

Active Health Surveillance Items

| Item | Start | Freq | Last Done | Due |
|---|---|---|---|---|
| WELL-CHILD CARE | 18-Jun-95 | 1y | | 18-Jun-95** |
| 20-44 VENOUS LEAD | | 7d | 28-Jun-95 | 5-Jul-95** |

**Overdue Report.**

Overdue items: For patients due before 17-Jul-95. Sorted by pt name.

| Name | Pat # | Chart # | Phy | Item | Freq | Last Done | Due |
|---|---|---|---|---|---|---|---|
| Ashback, Teddy Jr. | 68076 | 00367843 | 1243 | 15-19 Cap Lead | 1m | 8-Aug-94 | 8-Sep-94 |
| Ashpaul, Wilson III | 69810 | 00373088 | 1354 | 10-14 Cap Lead | 3m | 23-Aug-94 | 21-Nov-94 |
| Bryce, Lonzo Jr. | 74963 | 00416592 | 1356 | 20-44 Ven Lead | 7d | 4-May-95 | 11-May-95 |
| Casswell, Rolando | 78273 | 00654523 | 1358 | 20-44 Ven Lead | 7d | 28-Jun-95 | 5-Jul-95 |

**Figure 1. Top–reminder attached to front of chart; bottom–overdue report used by nurse.**

**Table 3. Calculation of Costs per Year of Successful Follow-up for 66 Children with Abnormal Lead Concentrations.**

| Item | Calculation | Cost per Year ($) |
|---|---|---|
| Registered nurse time | 6 h/wk = 0.15 FTE RN @ $32,000/FTE | 4,800 |
| Phlebotomy time | 10 min/sample × 198 samples/year @ $10/h | 330 |
| Testing | 3 tests/child/yr × 66 children @ $26/test | 5,148 |
| Extra visits | 66 children × 2 extra physician visits @ $35/visit | 4,620 |
| Transportation | 198 samples @ $5/trip | 990 |
| Total | | 15,888 |

FTE = Full-time equivalent.

the office nurse, but none with abnormal screening results was omitted.

Capillary lead concentrations were obtained on 39 (70 percent) of 56 occasions when venous measurements were indicated by the protocol. The Family Health Center missed opportunities to obtain lead measurements during 110 (31 percent) of 355 visits by children who were overdue for lead screening.

### *Follow-up Rates and Degree of Elevation of Lead Concentrations*

Forty-eight of 67 children (72 percent) who had a lead concentration of 10 to 14 μg/dL, 16 of 24 children (67 percent) who had a lead concentration of 15 to 19 μg/dL, and 7 of 8 children (88 percent) who had a lead concentration of 20 μg/dL or greater were at least 1 month overdue for follow-up lead testing.

### *Interventions*

Thirty-two families with children having lead concentrations of 15 μg/dL or more were supposed to receive education about reducing lead exposure; only nine charts (28 percent) showed documentation of this education. Seventeen children required referral to the Allegheny County Health Department for environmental intervention based on the protocol, but only 7 (41 percent) were actually accepted as referrals by the health department, because they did not have staffing to handle children with concentrations less than 20 μg/dL. No child was removed from a dwelling, nor did any require chelation. Free bus fare and taxicab passes were provided to families on demand to eliminate transportation barriers, but no data were collected systematically to analyze the effect.

### *Effort*

Each week the office nurse responsible for providing follow-up for children with abnormal lead concentrations spent 5 to 6 hours reviewing charts, contacting physicians, finding test results, locating patients, arranging appointments, and documenting actions. The nurse succeeded in reaching approximately 8 families per week, and normally gave out taxicab passes to 3 of them to bring children in for testing. Very little effort was expended by physicians to assure follow-up of minimally elevated lead concentrations as a result of the nurse-centered system used.

### *Cost*

The estimated cost to the practice of successful follow-up of abnormal results, as distinguished from the already formidable cost of screening, is displayed in Table 3, assuming 66 children with abnormal lead concentrations per year have an average of three blood lead tests in the year to clarify the child's status and two additional physician visits (to explain the need for added testing, to give advice on avoiding lead exposure, and to report the final results of evaluation). These estimates do not include costs to parents and guardians who might miss work to bring children in for care.

### *Benefit*

It is uncertain whether children with lead concentrations of less than 20 μg/dL benefit from a reduction in lead test values.[8] Only 8 percent of children with elevated blood lead concentrations had values of 20 μg/dL or greater. Only 7 of 17 children who developed higher lead concentrations received environmental abatement services from the Allegheny County Health Department, because they did not have adequate resources. None of the children required chelation. The health department, however, was not able to find 1 child referred who had a follow-up capillary lead concentration of 73 μg/dL or her sister, who had a concentration of 38.4 μg/dL. No evidence exists of any benefit to children with lead concentrations of 20 μg/dL or greater as a result of efforts undertaken during the study period, though aggressive efforts are being continued to reduce their lead exposure and monitor their lead concentrations.

## Discussion

The nurse-centered, computer-aided tracking system for children with abnormal lead concentrations assigned every at-risk child to an appropriate initial follow-up plan. All physicians and parents of children with abnormal test results received reminders for additional testing. At least one follow-up measurement was obtained in 65 percent of children with an abnormal test result compared with 7 percent using the previous manual follow-up method. Nevertheless, considerable difficulty was encountered in following up on abnormal lead measurements, a problem that has not received attention in previous reports.

Many children were not brought back for follow-up care in spite of telephone calls, letters, taxicab passes, and visits by community health aides. In the study by Kimbrough et al[2] of children living in the vicinity of a defunct lead smelter, his group found 78 children with lead concentrations of 10 µg/dL or higher. Despite the considerable resources of the Illinois Department of Public Health, he was able to obtain 4-month follow-up measurements on only 51 of these children and 12-month follow-up measurements on only 30 children. In our study, the likelihood of at least one follow-up lead measurement was related to severity of the lead elevation, because greater effort was expended on the children with higher concentrations. Full CDC-mandated compliance was equally difficult in all children regardless of the severity of their abnormal levels, however. Elevated lead concentrations could easily be a marker for the same chaotic lives that make follow-up difficult.

The difficulty encountered in bringing children back for retesting makes the problem of missed opportunities that much more important. Many children did not receive needed repeated lead testing even though they appeared for care of other problems. Their physicians and nurses either did not see, did not heed, or did not agree with the overdue lead-testing reminders on the front of the chart. Campbell et al[9] found similar problems while screening for lead poisoning at their Rochester Pediatric Primary Care Center and determined that nearly one half of the missed opportunities occurred during well-child visits. Regular staff reeducation and improved visibility of reminders might remedy some of these omissions.

When retesting was accomplished, capillary, rather than the more accurate venous, samples were frequently obtained by nursing staff, sometimes because they misunderstood the protocol, but most often because of time constraints and inadequate availability of phlebotomy services. Venipuncture would be a more cost-effective screening strategy.[10] Training more nurses to perform venipuncture on infants and children, with back-up by physicians when initial attempts fail, might improve this situation.

Educational intervention about avoiding lead exposure was poorly documented but, based on discussions with physicians, was usually provided. Educational materials could accompany all reminder mailings to families of affected children to supplement parent-physician discussions. Kimbrough et al[2] showed that educational materials might help parents learn how to control dust in their homes.

Although no children with elevated lead concentrations were missed, 22 percent of children with initially abnormal lead concentrations were inappropriately kept in the automated tracking system. In actuality, this misclassification represented little risk because, as a result of incomplete follow-up, only 2 children were unnecessarily tested for lead.

The Shadyside Hospital residency-based Family Health Center is insulated from many of the financial pressures of unsubsidized practice, and its staffing levels and information systems are much better than the average. Financially strapped private and public practices with lower staffing levels would have even more difficulty in following up abnormal lead-screening results.

The distribution of abnormal lead concentrations in this practice was similar to that reported by other practices (Table 4). If the findings in this

**Table 4. Distribution of Abnormal Lead Concentrations in Various Locales.**

| Location | Percent with 10-14 µg/dL | Percent with ≥ 20 µg/dL |
|---|---|---|
| Shadyside, Pa 1995 | 68 | 8 |
| Allegheny County, Pa 1994[11] | 65 | 13 |
| Rochester, NY 1992[1] | 71 | 18 |
| Vermont 1992[12] | 67 | 15 |
| Orange County, Calif 1992[13] | 82 | 4 |
| Minn-St. Paul 1992[4] | 64 | 20 |

study also reflect the costs and failures of mandated follow-up in other practices, the CDC guidelines should be changed. Screening for lead concentrations of less than 20 µg/dL has been criticized as needlessly expensive because it is of no proven value.[8] Raising the level of lead concentration that would require follow-up would make a huge difference in the ability of practices to cope with the children at higher risk. For the practice observed in this study, a screening concentration of 15 µg/dL would have reduced the work load by nearly 70 percent, and a threshold concentration of 20 µg/dL would have reduced the work load by 92 percent.

## Conclusion

The burden exacted by aggressive follow-up of small abnormalities found on lead-screening tests could not be managed by traditional manual record-keeping and office procedures. A combination nurse-centered, computer-aided system was implemented and evaluated after 18 months of use. Despite considerable improvement in follow-up, important deficiencies remained. Although changes in staff education and work allocation theoretically might help to remedy some of these shortcomings, the current CDC recommendations appear to be unnecessary and impractical, even with extraordinary effort. The CDC recommendations should be modified to focus dwindling resources on the children at greatest risk.

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Cassie Avon, RN, implemented the lead-screening program at the Shadyside Family Health Center.

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