damage, determination of IL-6 might be of value in evaluating 
new techniques in CPB to improve biocompatibility.

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Mass screening of children for increased blood lead 
(I–5) requires easy and convenient methods of blood 
collection. Here we compare reference methodology graph-
iete furnace atomic absorption spectrophotometry (GFAAS) 
with a second-generation (2nd-Gen) filter-paper collection-
based Delves cup–flame atomic absorption spectro-
photometry (FPDC) procedure.

A split-sample, double-blind study design was used to 
compare the micro-GFAAS (6, 7) and the 2nd-Gen FPDC 
(8, 9) procedures. Laboratories 1 and 2 (Montefiore and 
Columbia University Presbyterian Medical Center) used 
the GFAAS method, whereas laboratory 3 (New York City 
Dept. of Health) used the 2nd-Gen FPDC method. Labo-
atories 1 and 2 collected and analyzed 101 and 66 venous 
bleed samples, respectively, and sent them to laboratory 3 as 
liquid samples (laboratory 1) or as samples spotted onto 
filter paper (no. 903; Schleicher & Schuell, Keene, NH) 
and stored in zip-lock bags (laboratory 2). Statistical 
analyses were performed at Columbia Presbyterian.

A second study, performed in a clinical setting at the 
Yale University School of Medicine, was part of a larger 
study of screening methods for lead poisoning (n = 1573) 
in an urban pediatric clinic with fingerstick samples (10). 
After a single fingerstick, blood was collected into a 50-μL 
micropipette for micro-GFAAS analysis, and an additional 
5–8 drops of blood were absorbed onto filter paper for 
FPDC analysis. The filter-paper blood samples were ana-
lyzed by an older procedure (11) (1st-Gen) FPDC, at the 
CT Dept. of Health (DOH) Laboratory. The capillary 
samples were analyzed at the Clinical Chemistry Labora-
tory at Yale–New Haven Hospital by GFAAS in a modifi-
cation of the method of Carrnick and Slavin (12).

In the second study, zinc protoporphyrin (ZPP) was 
measured immediately at the same time that the finger-
stick specimens were obtained, and a confirmatory venous 
sample was obtained at the same visit if the ZPP was >35 
μg/dL (1.68 μmol/L). Children with either a filter-paper or 
capillary lead value ≥15 μg/dL (0.72 μmol/L) were called 
back, and venous blood was obtained and analyzed by 
GFAAS (12). The average delay between the screening 
and the confirmatory testing was 30 days.

After analyses, some filter-paper blood samples (n = 252) 
from the CT DOH Laboratory were sent to the New 
York City Health Department, Bureau of Laboratories (n = 102), and some to Leadtech Corp. (North Bergen, NJ) (n = 150) for reanalysis by the 2nd-Gen FPDC procedure (8). The 252 filter-paper samples from the CT DOH were 
selected without conscious bias from those with sufficient 
sample volume for reanalysis. At the reanalysis 44.4% 
(112) of the samples had lead concentrations >15 μg/dL 
(0.72 μmol/L), needing venous confirmation. Results were 
not released until all analyses were completed.

Figure 1 shows the results of the 2nd-Gen FPDC proce-
dure (8) vs micro-GFAAS procedures (6, 7). A total of 167 
split samples were analyzed under laboratory settings. 
Specifically, the blood samples were spotted onto filter 
paper in the laboratory where the micro-GFAAS analyses 
were performed, and sent, without reporting the results, 
to laboratory 3 for FPDC analyses. Under these condi-
tions, the 2nd-Gen FPDC (γ) and GFAAS (α) methods 
agreed well: y = 0.88 (± 0.013)x + 1.91 (± 0.284), Sα = 2.537, r = 0.98.

The second study, which mimicked routine screening 
operations, compared three analytical procedures 
(GFAAS, 1st-Gen FPDC, and 2nd-Gen FPDC) and three

Blood Collection and Analytical Considerations in 
Blood Lead Screening in Children, Karl Verebey,1, 8 John F. Rosen,2 David J. Schonfeld,3 Damaris 
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collection techniques (fingerstick filter paper, fingerstick capillary, and venous collections). The screening methods were then similar, in agreement with the venous blood confirmation by GFAAS. The regression statistics were as follows: For the 2nd-Gen FPDC (y) and the venous confirmation by GFAAS (x), \( r = 0.87, y = 0.915 \pm 0.050x + 4.51 \pm 0.882 \), \( S_{xy} = 5.523 \); for capillary samples analyzed by GFAAS (y) and the venous blood GFAAS (x), \( r = 0.80, y = 0.692 \pm 0.050x + 7.586 \pm 0.879 \), \( S_{xy} = 5.509 \); and \( r = 0.82, y' = 0.857 \pm 0.057x + 8.045 \pm 1.014 \), \( S_{xy} = 6.364 \). Better correlation and regression parameters would be expected if all the venous samples (reference method) were drawn on the same day as the screening samples (10).

The Centers for Disease Control and Prevention recommends universal blood lead screening in children between ages 6 months and 6 years. Since the major lead screening test, free erythrocyte protoporphyrin (FEP), is judged ineffective at the new recommended intervention concentrations of 10 \( \mu \)g/dL (0.48 \( \mu \)mol/L) lead (1, 3), alternative screening methods were evaluated. Venous blood collection with GFAAS analyses is the procedure of choice for accurate blood lead analysis. However, instrumentation is expensive, relatively large blood samples are required for analyses, and collection of samples is often traumatic for children. A practical accurate initial screening test is needed to fill the void of FEP as a screening method.

An early evaluation of the filter-paper collection method was disappointing (13), but the filter-paper samples were stored unprotected in open containers. Current filter-paper collectors are individually wrapped in zip-lock bags, which ensures exclusion of contaminants. A recent study concluded that appropriately performed capillary sampling is a viable alternative to venipuncture for lead poisoning screenings in young children (14). We concur with Schlenker et al. (14) that proper cleaning of the collection site with soap and water and controlling for lead-free blood collection supplies prevents environmental contamination. We at Leadtech also: (a) educate the nursing staff to avoid touching anything with the cleaned finger before completing sample collection, (b) use only lots of filter paper for which lead was undetectable, and (c) check samples with lead >10 \( \mu \)g/dL (0.48 \( \mu \)mol/L) by punching a blank spot next to the sample and analyzing the blank to ascertain that the filter-paper collector was not contaminated during collection.

As the results of these multicenter studies show, the current 2nd-Gen FPDC procedure correlates well with GFAAS methods. Thus FPDC offers an alternative procedure to capillary blood-based screening. The advantages are: (a) one or two drops of blood are easily obtained after a single fingerstick; (b) blood samples spotted onto the filter-paper collector are stable for at least 6 months, whereas venous blood and capillary blood samples should be analyzed within 4–5 days after collection; and (c) the dried blood spots on filter paper are convenient to process and transport to the laboratory, whereas venous and capillary blood samples may spill, clot, or break.

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