A Comparison of Elevated Blood Lead Levels Among Children Living in Foster Care, Their Siblings, and the General Population

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ABSTRACT. Objectives. To assess the prevalence of elevated blood lead levels (EBLLs) among children before and after foster care placement, and to compare the prevalence of EBLLs among children in foster care with that of their siblings and the general population.

Methods. We conducted a retrospective cohort study using administrative databases from the Philadelphia Department of Human Services and the Birth Certificate Registry and the Childhood Lead Poisoning Prevention Program at the Philadelphia Department of Public Health. Logistic regression analyses were performed to control for confounding variables, including age, race, gender, and the year, seasonal timing, and source (capillary vs venous) of test.

Results. From June 1992 to May 1997, there were 1824 children in foster care with available blood lead results in the Childhood Lead Poisoning Prevention Program database. Of these, 519 (28%) had initial lead screening before foster care placement and 654 (36%) after placement. There were 821 siblings and 73 608 children in the general population with available blood lead results.

Before entering foster care, children were nearly twice as likely to have EBLLs as their siblings (adjusted odds ratio [OR] = 1.7; 95% confidence interval [CI] = 1.4, 2.0), those in placement (adjusted OR = 1.9; 95% CI = 1.6, 2.2), and the general population (adjusted OR = 1.7; 95% CI = 1.5, 2.0). At the highest point prevalence, 50% of children before placement had lead levels ≥20 µg/dL, and nearly 90% had levels ≥10 µg/dL. For all age categories, siblings of children in foster care placement had a higher prevalence of EBLLs than did the general population. After placement, children in foster care were nearly half as likely as the other groups to have EBLLs.

Conclusions. Our findings suggest that children are at high risk for lead poisoning before entering foster care and that placement in foster care may have a beneficial effect on lead exposure. Children before foster care placement are nearly as likely to have EBLLs compared with children in foster care placement, the general population, and their siblings. Furthermore, siblings of children in foster care are at high risk for lead poisoning. Children receiving social services in their own homes and children suffering from abuse and neglect should be actively screened for lead poisoning. Greater efforts at preventing lead poisoning among these children must be made. Pediatrics 2001;107(5). URL: http://www.pediatrics.org/cgi/content/full/107/5/e81; blood lead levels, lead poisoning, foster care, child welfare, child abuse.

ABBREVIATIONS. EBLLs, elevated blood lead levels; NHANES, National Health and Nutrition Examination Survey; FACTS, Families and Child Tracking System; CLPPP, Childhood Lead Poisoning Prevention Program; pre-FCP, pre-foster care placement; post-FCP, post-foster care placement; OR, odds ratio; SCOH, Services to Children in Their Own Homes; CI, confidence interval.

Lead poisoning, a widespread environmental health problem, affects an estimated 890 000 children living in the United States. It has been associated with many adverse outcomes, including decreased intelligence, impaired neurobehavioral development, decreased stature, hearing abnormalities, and learning difficulties. High rates of lead poisoning are found among urban, poor, and minority children, and children residing in older housing.

Currently, lead poisoning is most commonly detected by screening young children with blood lead level determinations (secondary prevention) and treatment of affected individuals. Title X of the Housing and Community Development Act of 1992 was instrumental in shifting the focus of lead-poisoning prevention from a secondary to a more primary mode, by addressing the evaluation and control of lead-based paint hazards in both federally assisted housing and US housing in general. Blood lead screening still remains the predominant mode of case detection.

The national prevalence of elevated blood lead levels (EBLLs) has decreased considerably from the 1970s until the present, as shown by data obtained during periodic surveys known as the National Health and Nutrition Examination Survey (NHANES). Factors found to be associated with EBLLs include the year and season in which testing was performed, the source of blood lead testing (venous vs capillary), and age.

Children living in poverty represent a high-risk group for lead poisoning, but only 20% to 30% are screened. Even after recommendations for universal lead screening were in place, as few as 24% of young children had been screened for lead poisoning.

In 1997, the Public Health Service published
Screening Young Children for Lead Poisoning: Guidance for State and Local Public Health Officials. In this document, targeted screening recommendations state that high-risk children, including those receiving services from public assistance programs for the poor (eg, Medicaid, the Supplemental Food Program for Women, Infants, and Children), should be screened at 1 and 2 years old, and at 36 to 72 months old, if not previously screened. According to a 1999 Government Accounting Office Report, children served by federal health care programs account for 75% of children ages 1 to 5 years with lead poisoning; however, <20% of these children are screened for lead poisoning. Children entering foster care are at risk for lead poisoning for several reasons. Many have a history of child abuse and neglect (85%), developmental delays (53%–84%), behavioral problems (35%–95%), failure to thrive, and living in poverty. Each of these conditions has been associated with an increased prevalence of lead poisoning.

To date, there are no known studies that assess the prevalence of EBLLS among children in foster care with relation to the time of placement or in comparison to other groups of children. In this study, we use administrative data: 1) to compare the prevalence of EBLLS in children before and after foster care placement; and 2) to compare the prevalence of EBLLS among children in foster care with those of their siblings and the general population.

METHODS

Participant Selection and Data Collection

We used 3 databases in our study: the Families and Child Tracking System (FACTS) database, the Childhood Lead Poisoning Prevention Program (CLPPP) database, and the Birth Certificate Registry. The FACTS database at the Philadelphia Department of Human Services contains demographic and social information on all children in out-of-home care (which includes foster families, group homes, and institutional settings) in Philadelphia County. The CLPPP database at the Philadelphia Department of Public Health contains demographic information and blood lead levels on all children with lead testing reported to the CLPPP or performed by the Philadelphia Public Health Lead Laboratory after 1990. Most clinical facilities in Philadelphia use this laboratory to process lead-screening tests. For those sites that do not use this laboratory, the majority of specimens are sent to a single, private laboratory that generally reports lead levels ≥15 μg/dL to CLPPP. It is required that all levels ≥5 μg/dL and requested that all levels ≥15 μg/dL be reported to the CLPPP. For this study, we used lead result data from January 1992 to February 1998. The Birth Certificate Registry of the Pennsylvania Department of Vital Statistics for Philadelphia contains demographic and perinatal information on all children born in Philadelphia County. The 3 databases mentioned above are independently used for perinatal information on all children born in Philadelphia County. The CLPPP database at the Philadelphia Department of Human Services contains demographic and social information on foster families, group homes, and institutional settings in Philadelphia County. The Birth Certificate Registry. Siblings were identified in the CLPPP database to obtain initial lead-screening results. The fourth cohort consisted of the general population, which included the remaining children in the CLPPP database who were not in foster care or siblings of those in foster care, with initial lead-screening results.

We conducted a retrospective cohort study based on cross-linkage and analysis of secondary data. We included the following variables from FACTS in our analysis: the child’s sex, race, reason for placement, date of entry into and exit from initial foster care placement, and number and type of foster care placements. From CLPPP, we included the child’s date of birth, date of initial lead screening, blood lead level (μg/dL), and source of blood for testing (capillary vs venous). Children were defined as having EBLLS if their levels were ≥10 μg/dL and 20 μg/dL.

Unique identifiers including mother’s name and social security number and child’s name and date of birth were used for crosslinking datasets. Names were eliminated from the datasets to ensure confidentiality once the cohorts were defined. Permission to use the FACTS database for research purposes was granted by the Office of Children, Youth, and Families at the Pennsylvania Department of Public Welfare. The institutional review board at the affiliated hospital approved this study.

Statistical Analysis

χ² analysis was performed for dichotomous variables. For continuous variables with normal distributions, the Student’s t test was used, and for nonparametric data the Wilcoxon rank sum test was used. A P value of ≤.05 was considered statistically significant.

Logistic regression analyses were performed to control for confounding variables.

RESULTS

Study Participants—Foster Care Cohorts: Pre-FCP and Post-FCP Groups

From June 1, 1992 to May 31, 1997, there were 9184 children initially placed in foster care in Philadelphia County. Of these, 1832 children (20%) had available lead-screening results in the CLPPP database. Eight participants were dropped from the study because their age at the time of lead testing or foster care placement could not be defined because of incomplete information. Therefore, our analysis was based on 1824 children in foster care with available lead-screening results.

The pre-FCP group consisted of 519 children (28%) in foster care with initial lead screening performed before foster care placement. The post-FCP group consisted of 654 children (36%), who had lead screening performed ≥30 days after initial placement and before leaving foster care. The remainder (n = 651; 36%) had lead screening performed <30 days after placement or sometime after leaving their first stay in foster care. These participants were dropped from the study.

Sibling Cohort and the General Population

Two thousand two hundred forty-six siblings of children in foster care were identified from the Birth Certificate Registry. Eight hundred twenty-one (37%) had lead-screening results in the CLPPP database. The general population consisted of 73,608 children with lead-screening results in the CLPPP database. Age, gender, and source of blood lead test for all 4 groups are shown in Table 1.
Prevalence of Elevated Blood Lead Levels

Figures 1, A and B show the prevalence of EBLLs by for various age categories in all 4 groups at lead levels $\geq 10 \mu g/dL$ and $\geq 20 \mu g/dL$, respectively. At ages 19 to 24 months, 53% of all children with initial lead screening before foster care placement had lead levels $\geq 20 \mu g/dL$, whereas 12% of those tested after foster care placement had lead levels $\geq 20 \mu g/dL$. For nearly all age categories, the pre-FCP group had the highest prevalence of EBLLs and the post-FCP group overall had the lowest prevalence of lead poisoning. For all age categories, siblings of children in foster care placement had a higher prevalence of EBLLs ($\geq 10 \mu g/dL$ and $\geq 20 \mu g/dL$) than did the general population. As shown in Fig 1, overall trends were similar for blood lead levels $\geq 10 \mu g/dL$ and 20 $\mu g/dL$.

Multiple Logistic Regression Analyses

Data were available on the following potential confounding variables: age, race, gender, and the year, seasonal timing, and source (capillary vs venous) of test. Logistic regression analyses were performed, controlling for these variables. Comparing the pre-FCP group with the other groups, we obtained the odds ratios (ORs) shown in Table 2 for children with lead levels $\geq 10 \mu g/dL$ and $\geq 20 \mu g/dL$. Children screened before foster care placement were nearly twice as likely to have EBLLs than were their siblings, children tested while in foster care placement, and the general population. Similarly, Table 3 shows the ORs obtained when the post-FCP group was used as the comparison group for lead levels $\geq 10 \mu g/dL$ and $\geq 20 \mu g/dL$. Children screened while in foster placement were half as likely as were their siblings, the general population, and children screened before entering foster care to have lead poisoning.

DISCUSSION

Our study demonstrates that integrating administrative databases is a useful means of assessing the prevalence of lead poisoning among children in foster care and selected groups of other children. The FACTS database alone lacks health information on children in foster care. When FACTS was integrated with the CLPPP database, we were able to assess the prevalence of lead poisoning for children in foster care. We were able to identify and determine blood lead levels on siblings of children in foster care by adding a third database, the Birth Certificate Registry.

In the absence of a computerized medical database, it is difficult to assess trends in the health of children in foster care, making it difficult to know where to target health services for these children. The idea of integrating public agency databases is a logical approach in Philadelphia, where there are many databases containing overlapping and complementary information.

The limitations of using administrative datasets for research purposes are well described and apply to our study. These limitations include missing and
Controlling for age, race, gender, and year, seasonal timing, and source of test. Large differences were seen between children of abuse and neglect. In our study, 1 in 5 children in foster care had levels $\geq 10 \mu g/dL$ and required treatment for lead exposure. One might speculate that removing children from home situations that have been deemed unfit by the child welfare system and placing them in foster care may have a beneficial effect on lead exposure. One might speculate that such a finding is the result of several factors, including improved housing circumstances, improved nutrition, and greater parental supervision. This finding is hopeful given that the press media all too often erroneously data. In our study, potential participants were dropped from the study if crucial information used to crossmatch was missing and/or if such information did not correlate among databases.

Because our study was limited to Philadelphia, the results may not be generalizable to children living in other areas. Our study is based on available lead-testing results in CLPPP and, therefore, is limited to those tests that were either processed by or reported to CLPPP. Because outside laboratories generally report EBLLs $\geq 15 \mu g/dL$ and are required to report levels $\geq 25 \mu g/dL$, 1 limitation of our study may be recording bias. For example, if outside laboratories only reported EBLLs $\geq 25 \mu g/dL$ and there was underreporting of blood lead levels between 10 and 25 $\mu g/dL$, the true prevalence of EBLLs between 10 and 25 $\mu g/dL$ may have been underestimated. This type of bias would affect all 4 groups studied. We believe that reporting bias in our study is likely to be very small given that the majority of clinical facilities in Philadelphia use the public health laboratory associated with CLPPP for processing of all lead-screening tests.

Children tested before entering foster care had a higher prevalence of EBLLs than did the general population. This is consistent with previous studies of children of abuse and neglect. In our study, 1 of every 2 children screened before placement had blood lead levels $\geq 20 \mu g/dL$ at the peak prevalence (at ages 19–24 months), and nearly 9 of 10 children had levels $\geq 10 \mu g/dL$. These findings are alarming and disproportionate to the general population.

Our study also shows that siblings of children in foster care are at very high risk for lead poisoning. The unexpected finding was that children screened while in foster care placement had the lowest prevalence of EBLLs of all 4 groups, including that seen in the general population. After placement, children were nearly one half as likely as the other groups to have lead poisoning. This suggests that removing children from home situations that have been deemed unfit by the child welfare system and placing them in foster care may have a beneficial effect on lead exposure. One might speculate that such a finding is the result of several factors, including improved housing circumstances, improved nutrition, and greater parental supervision. This finding is hopeful given that the press media all too often highlights adverse outcomes to children in foster care rather than pointing out potential benefits of foster care.

We did not have access to information on foster parents and, thus, were not able to compare the prevalence of EBLLs for children in foster care with that of the biological children of foster parents. Knowing this information would help to elucidate the impact of the foster care home environment. Additional studies are needed to assess the impact of foster care placement on lead exposure and other health outcomes.

The results of our study suggest that foster placement has a beneficial effect on lead exposure. In our study, we compared EBLLs for children pre-FCP and post-FCP. Our criteria for post-FCP were strict (ie, required that children had available blood lead test results while in foster care placement but at least 30 days after placement) and limited the number of children who we were able to study. When we attempted to limit the post-FCP group further by including only those who also had a blood lead test available pre-FCP, the numbers were too small to analyze. A longitudinal study looking at blood lead levels for the same children before and after foster care placement is needed. Longitudinal studies on children in foster care are generally difficult to conduct given that these children move from placement to placement and health care provider to health care provider, staying for variable lengths of time.

Results of our study confirm that lead poisoning continues to be a major problem for children living in Philadelphia. The prevalence of EBLLs in Philadelphia children, although declining in past years, remains high compared with national prevalence data estimated from the NHANES data. Although the most recent NHANES data show that 2.2% of the population and 4.4% of children ages 1 to 5 years have lead levels $\geq 10 \mu g/dL$ data from the Philadelphia Department of Public Health show that 30.5% of reported screening results were $\geq 10 \mu g/dL$ in 1998 (unpublished data). The high prevalence of EBLLs in Philadelphia is believed primarily to be the result of lead-based paint exposure from old housing, especially that which has been poorly maintained. More than 50% of the $600,000$ occupied housing units were built before the 1940s, and 95% were built before 1978, when lead-based paint for residential

### Table 2. Logistic Regression Analyses Comparing Pre-FCP Group With Other Groups for Lead Levels $\geq 10$ and 20 $\mu g/dL$\textsuperscript{a}

<table>
<thead>
<tr>
<th></th>
<th>Pre-FCP Versus Post-FCP</th>
<th>Pre-FCP Versus Siblings</th>
<th>Pre-FCP Versus General Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjusted OR</td>
<td>1.9 (1.8)</td>
<td>1.7 (1.7)</td>
<td>1.7 (1.7)</td>
</tr>
<tr>
<td>95% Confidence interval</td>
<td>1.6, 2.2 (1.5, 2.2)</td>
<td>1.4, 2.0 (1.4, 2.1)</td>
<td>1.5, 2.0 (1.1, 1.5)</td>
</tr>
</tbody>
</table>

\textsuperscript{a} Controlling for age, race, gender, and year, seasonal timing, and source of test.

### Table 3. Logistic Regression Analyses Comparing Post-FCP Group With Other Groups for Lead Levels $\geq 10$ and 20 $\mu g/dL$\textsuperscript{a}

<table>
<thead>
<tr>
<th></th>
<th>Post-FCP Versus Pre-FCP</th>
<th>Post-FCP Versus Siblings</th>
<th>Post-FCP Versus General Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjusted OR</td>
<td>0.5 (0.6)</td>
<td>0.5 (0.5)</td>
<td>0.5 (0.6)</td>
</tr>
<tr>
<td>95% Confidence interval</td>
<td>0.5, 0.7 (0.4, 0.7)</td>
<td>0.4, 0.5 (0.4, 0.6)</td>
<td>0.5, 0.8 (0.5, 0.6)</td>
</tr>
</tbody>
</table>

\textsuperscript{a} Controlling for age, race, gender, and year, seasonal timing, and source of test.
purposes was banned by the Consumer Product Safety Commission.

In Philadelphia, the majority of children enter foster care while receiving social services through a program called Services to Children in Their Own Homes (SCOH). SCOH is provided to families identified to be at high risk for abuse and neglect. Based on our finding that nearly 1 of every 2 children screened before foster care placement at the peak prevalence had EBLs, we would recommend that all children receiving SCOH services, including children at risk for foster care placement and their siblings, undergo lead screening. This recommendation is consistent with the Public Health Service target screening recommendations.\(^1\) Previous studies also support screening of children at high risk for abuse and neglect.\(^2\)

Furthermore, increased efforts should be made to educate health care providers and child welfare workers about the hazards of lead exposure. Enhanced efforts should be made to ensure that all children at high risk for foster care placement, their siblings, and those in foster care placement are screened for lead poisoning.

**ACKNOWLEDGMENTS**

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