Effectiveness of a Pediatric Verbal Lead Exposure Screening Protocol in Emergency Department Patients

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Purpose: The population demographics found in many urban emergency departments (EDs) often mirrors those of children at risk for elevated serum lead levels. We evaluated the effectiveness of a verbal lead screening program for screening high-risk children presenting to the ED.

Methods: A prospective observational cohort study was conducted of children aged 9 months to 6 years, living in 2 target counties and presenting to an urban, academic, Midwestern ED. Those with a prior lead level, enrolled in a program requiring lead testing, or with an unstable medical condition were excluded. A 6-question validated verbal survey was administered to all parents of eligible children, and the results recorded in the patient's electronic medical record. Children who screened positive were referred to their local health department for blood lead testing. Health department records were reviewed for follow-up visits and blood lead levels.

Results: During the study period, 3513 children were eligible (mean age, 2.6 years; 53.3% male), with 815 patients screened and 209 (25.6%) screening positive. Most positively screened patients (71.8%) documented only 1 affirmative question, most often indicating they lived in a home built before 1978. Of those children who screened positive, 14.8% (31/209) had a blood lead level performed within 6 months. Of those tested, 4 children had an elevated lead level (>10 µg/dl).

Conclusions: Use of an ED verbal lead exposure screening tool identified children requiring additional follow-up testing. However, health department-referred children had poor follow-up, and few children were ultimately documented with elevated lead levels.

Key Words: screening protocol, lead exposure, health department

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Of all the potentially toxic heavy metals, lead is easily one of the most prevalent and common environmental exposures in the United States. When considering the impact in the United States, the Centers for Disease Control and Prevention found that, in 2006 alone, nearly 40,000 children younger than 6 years were screened and confirmed to have an elevated blood lead level (BLL) of at least 10 µg/dl. Illinois makes up nearly 10% of the national yearly cases and has the highest incidence of pediatric elevated lead levels in the country (BLL ≥10 µg/dl). Illinois is known if the practice of risk stratification using a verbal screening tool with subsequent referral for formal lead screening will be effective in this population. Thus, we evaluated if the impact of lead exposure in high-risk children who presented for usual care to an ED.

Current state guidelines require universal screening by every licensed physician and health care facility for children between 6 months and 6 years of age with BLL screening or through the use of a risk assessment questionnaire to determine high-risk populations followed by screening those in a high-risk category.² Lead risk assessment and screening studies have shown that screening questionnaires used within a pediatrician’s office are up to 90% sensitive for detecting elevated BLLs with a corresponding negative predictive value of 99%.³

Most public health research involving lead intoxication has been focused on the utilization of lead screening in a primary care setting. The use of standardized lead screening in other potential health care venues that may substitute as primary care for those patients lacking a medical home has not been studied. One such health care venue is the hospital emergency department (ED), as many underserved pediatric and adult patients utilize this location both for emergent illnesses as well as for primary care. These patients have a tendency to underutilize primary care physicians because of many factors, including “firing” as patients from chronic absenteeism and missed appointments, not being able to see a physician without having made a prior appointment or not having a primary care physician at all.⁴ Patients who frequent the ED tend to have a high number of independent risk factors for lead intoxication including low income, Medicaid insurance, and minority race.⁵

With the recommendation by the Illinois Department of Public Health (IDPH) that all physicians should be screening children for elevated BLLs, the Children’s Hospital of Illinois at OSF Saint Francis Medical Center (CHOI/SFMC) Department of Emergency Medicine in Peoria began to implement a screening protocol.⁶ The CHOI/SFMC ED implemented the standardized IDPH risk assessment questionnaire that is required to be administered to all pediatric patients presenting to the ED between the ages of 9 months and 6 years. However, it is currently unknown if the practice of risk stratification using a verbal screening tool with subsequent referral for formal lead screening will be effective in this population. Thus, we evaluated if the impact of this standardized, validated lead risk assessment questionnaire, with a subsequent discharge referral to the local health department for formal BLL screening, was an effective method for identifying high-risk children who presented for usual care to an ED.

METHODS

Study Design

This was a retrospective cohort study of children aged 9 months to 6 years presenting to the CHOI/SFMC ED between July 2007 through December 2007.

Study Population

The CHOI/SFMC is located in Peoria, III, which has an urban population of 115,007 in 2010, and serves as the primary tertiary referral hospital for the surrounding 6-county Central Illinois region. The tricounty area, consisting of Tazewell, Peoria, and Fulton Counties, ranks fourth among Illinois metropolitan statistical areas (behind Chicago, East St Louis, and...
Rock Island) with more than 350,000 residents. According to the 2010 Census, Peoria County has a population of 186,494, with more than 25% younger than 18 years. The City of Peoria encompasses a socioeconomically and ethnically diverse urban population composed of 86 separate, cohesive neighborhoods. In the older neighborhoods of the City of Peoria, 84% of homes were built before 1970, and 56% of the units are renter occupied. The CHOI/SFMC is located in an economically challenged area in the City of Peoria and represents the primary medical safety net hospital, meeting both Medicare and Medicaid criteria for a disproportionate share hospital. The CHOI/SFMC admits more than 5000 children from 60 counties and annually completes more than 70,000 ED visits, of which 15,000 represent children younger than 18 years (21%).

Subjects were identified using the electronic medical record and electronic order entry system utilized at OSF SFMC ED (EMSTAT; Allscripts Inc, Chicago, Ill) and abstracted. Subjects were included if they had a primary residence in the 2 largest immediate surrounding Illinois counties (Peoria and Tazewell Counties) and completed their ED visit. Subjects were excluded if their parent or guardian reported a previous lead screening assessment by a health care provider; utilized the Women, Infants, and Children Program; or were involved in specialized sponsored day care in which lead screening is mandated at enrollment (ie, Illinois KidCare). Repeated visits by the same child were also excluded.

Study Protocol

Subjects between 9 months and 6 years presenting to the ED had an automatic order generated for lead screening using a standardized IDPH 6-question survey recommended by the American Academy of Pediatrics for targeted lead screening.5 This screening has been previously used for targeted lead screening in primary care offices and was validated with a sensitivity of 75% and a specificity of 39% (Table 1).10 The survey was verbally administered to the child's parent or guardian during the initial nursing assessment and the responses recorded in the EMSTAT database. Nurses had the capability of canceling the screening questionnaire if the nature of the patient’s illness or injuries was severe, and a verbal screening would interfere with patient care (ie, severe multisystem trauma). Subjects were deemed to have a positive response to the screening questionnaire if they answered “yes” to any question. Those children who screened positive on the survey and reported not having had a previous blood lead performed were referred to the health department for further testing by verbal discussion and paper reminder. Figure 1 depicts subject enrollment. Questionnaire responses as well as other pretreatment and subject demographic variables were abstracted to a separate spreadsheet (Microsoft Excel 2003; Microsoft Corporation, Seattle, Wash). The cohort of patients who screened positive on the ED-administered questionnaire for potential lead exposure were queried in health department records to identify if they followed up at the county health departments for BLL measurement (Peoria City/County and Tazewell County Public Health Departments). Key variables and data were extracted from the state database (STELLAR [Systemic Tracking of Elevated Lead Levels and Remediation] version 2.2a; Department of Health and Human Services, Centers for Disease Control and Prevention, Washington, DC). These variables included time from ED visit to presentation at the county health departments (separated as BLL before ED visit—as parents were unaware that their child had been screened in the past, same-day visit, 1 day to 6 months, and >6 months), BLL recorded in the database (measured by venous draw and reported as μg/dL), and if the patient required follow-up from the county lead nurse. Follow-up was considered not performed if no health department visit was noted in the database within 180 days from the ED visit because blood lead testing after a 6-month break is considered to be a new screening test and because follow-up blood testing should occur in a timely manner after the positive screen.11

Statistical Methods

All data and variables acquired from both the ED electronic medical record and from the county health departments were analyzed using SPSS v17.0 (SPSS version 14.0; SPSS Inc, Chicago, Ill). Patients given the questionnaire were compared with those not given the questionnaire. Variables were compared using Pearson χ² test for categorical variables or t test for continuous variables. Both skewness and Levene test for equality of variance were inspected before using the t test. All reported P values were 2-sided. P < 0.05 was considered to indicate statistical significance. Individual County data were compared. Individual questions within the questionnaire were evaluated for correlation. Health department follow-up data were also compared with questionnaire responses.

RESULTS

During the study months (July 2007 to December 2007), 3513 eligible children from Peoria and Tazewell Counties were evaluated in the ED. Of those patients, 815 children (23.2%) received the risk assessment questionnaire. Of those children who received the questionnaire, 25.6% (209/815) had at least 1 positive response on the questionnaire and were referred for outpatient follow-up (Fig. 1). There were some significant differences between our screened and unscreened population, which can be found in Table 2. Noticeable differences between screened and unscreened patients were in ED diagnoses. Differences were most notable in the neurological category (3.3% unscreened vs 1.1% screened; P < 0.001) and the genitourinary category (0.7% unscreened vs 2.1% screened; P < 0.001). Unscreened children arrived more often by ambulance and helicopter (7.7% vs 0%; P < 0.001) and were more often admitted (10.7% vs 5.6%; P = 0.034). Screened children were more likely to have public aid insurance when compared with unscreened children (P = 0.003). According to the most recent census data from 2000, when compared with the state of Illinois, our patient population had a different racial distribution with a higher number of black (34.7% in our population vs 14.9% in Illinois), a lower number of Asian (0.5% vs 4.3%), and a lower percentage of Hispanics (3.6% vs 15.2%) as well as a lower female percentage (46.7% vs 50.7%).

Most of the positively screened patients documented only 1 affirmative response to the lead screening questionnaire

| TABLE 1. IDPH Lead Risk Assessment Questionnaire |
|------------------------------------------------|
| 1. Does this child have a sibling with a BLL of ≥10 μg/dL? |
| 2. Does this child live in or regularly visit a home built before 1978? |
| 3. In this past year, has this child been exposed to repairs, repainting, or renovation of a home built before 1978? |
| 4. Is this child a refugee or an adoptee from any foreign country? |
| 5. Does this child live with someone who has a job or hobby that may involve lead (eg, jewelry making, building renovation or repair, bridge construction, plumbing, furniture refinishing, or work with automobile batteries or radiators, lead solder, leaded glass, lead shots, bullets, or lead fishing sinkers)? |
| 6. At any time, has this child lived near a factory where lead is used (eg, a lead smelter or a paint factory)? |
(71.8%, 150/209), whereas 23.4% (49/209) had 2 affirmative responses, and 4.8% (10/209) had 3 affirmative responses. There was no significant difference (P = 0.17) in the rate of follow-up to the county health department based on the number of affirmative answers. The most commonly cited affirmative response on the lead risk assessment questionnaire was having lived in or frequently visited a home built before 1978 (Table 3). Of those patients who screened positive on the questionnaire, 35.4% (74/209) had a BLL drawn at either Peoria or Tazewell County Health Department, and only 14.8% (31/209) followed up within 6 months of their ED visit. The remaining BLLs from the health departments were done either before the ED visit (13.4%; 28/209) (indicating that family did not know or did not remember that one had been drawn at the time of ED lead screening) or greater than 6 months from their ED visit (7.2%; 15/209). The 74 patients with BLLs drawn at either Peoria or Tazewell County Health Departments, 4 were found to have a BLL greater than 10 μg/dL. All of these BLLs were drawn before the ED visit (Table 4).

**DISCUSSION**

It has been established that, in a pediatrician’s office, lead risk assessment questionnaires are effective methods of targeted screening for evaluating elevated BLLs.\(^4,10\) Our study looked to see if this tool would be effective in an ED setting with subsequent referral to a public health facility for further testing. Unfortunately, few children who screened positive with the lead risk assessment questionnaire followed up at the local health department for BLLs. In addition, those patients who had clinically elevated BLLs had received intervention before their presentation in the ED.

Of those 209 patients who screened positively on our risk assessment questionnaire, only 31 (14.8%) followed up with the local health department within the 6-month period previously established.\(^11\) A study by Kemper et al\(^11\) looked at the follow-up rate at local health departments after children had a documented elevated BLL in a primary care setting. Their follow-up rate was noted to be much higher (53.9%) than our population and may reflect differences in between primary care and ED populations. Also, in the study of Kemper et al,\(^11\) testing and follow-up were in the same location with the same staff, so the higher follow-up rate may be more of a testament to the diligence of the health department and physicians than to the diligence of the parents. This could have been remedied in our study if the local health departments had been notified by the ED of those patients requiring BLL testing rather than having the guardian and child self-report to the health department. Unfortunately, this is difficult in the ED setting, where patients present during off-hours.

![FIGURE 1. Included patients. *There were 28 BLLs that were drawn before their ED visit; 4 of those values were elevated.](peconline.com)
TABLE 2. Population Demographics

| Screened | Unscreened | P  |
|----------|------------|----|
| Total no. patients | n = 815 | n = 2698 | — |
| Positive questionnaire screens | 209 | n/a | — |
| Age (mean), y | 2.9 | 2.5 | <0.001 |
| Male (% of total) | 54.2% | 53% | 0.153 |
| Racial distribution (% of total) | | | |
| White non-Hispanic | 61.2% | 58% | 0.302 |
| Black | 32% | 35.5% | |
| Hispanic | 3.3% | 3.6% | |
| Asian | 0.5% | 0.4% | |
| Other | 2.7% | 2.4% | |
| Counties represented (% of total) | | | |
| Peoria | 73.9% | 74% | 0.947 |
| Tazewell | 26.1% | 26% | |
| ED arrival mode (% of total) | | | |
| Private vehicle | 100% | 92.3% | <0.001 |
| Ambulance/helicopter | 0% | 7.7% | |
| Insurance type (% of total) | | | |
| Medicaid | 63.6% | 66.6% | 0.003 |
| Private insurance | 28% | 22.6% | |
| No insurance/self-pay | 8.5% | 10.7% | |
| Primary ED Diagnosis (% of Total) | | | |
| Cardiovascular | 0.2% | 0.3% | 0.945 |
| Dermatologic | 9.4% | 7.2% | 0.056 |
| FEN | 1.3% | 2.1% | 0.156 |
| Gastrointestinal | 11.7% | 10.6% | 0.431 |
| Genitourinary | 2.1% | 0.7% | <0.001 |
| Hematologic | 0% | 0.3% | 0.120 |
| HEENT | 19.3% | 22.0% | 0.173 |
| Infectious disease | 32.8% | 31.2% | 0.557 |
| Musculoskeletal | 6.2% | 4.6% | 0.063 |
| Neurological | 1.1% | 3.3% | 0.001 |
| Respiratory | 9.6% | 11.2% | 0.239 |
| Trauma | 3.6% | 3.4% | 0.805 |
| Other | 2.7% | 3.1% | 0.591 |

Values in bold indicate statistically significant values (P < 0.05).

FEN indicates fluids/electrolytes/nutrition; HEENT, head/Eyes/ears/nose/throat.

TABLE 3. Positive Responses by Question

| Patients With Positive Responses (n = 209) |
|----------------------------------------|
| Sibling with elevated BLL | 5.7% |
| Live or visit building before 1978 | 88.0% |
| Renovation exposure to house built before 1978 | 27.3% |
| Refugee/adoptive from foreign country | 2.4% |
| Live with someone with job/hobby involving lead | 12.0% |
| Live near a factory where lead is used | 0% |

have caused more parental concern for parents than simply a positive questionnaire screen.

The low follow-up rate in this study suggests that, after a positive questionnaire, instead of referral for follow-up testing, a more effective intervention would be to perform BLL testing at the time of interaction in the ED. Although there have not been any studies looking at BLL testing in the ED, there have been a few prior studies looking at other basic health screenings in the ED. Mandelblatt et al.12 showed that “point-of-care” screening (for breast and cervical cancer) was mixed in its cost-effectiveness and depended on the volume of patients seen. There have also been studies evaluating the cost-effectiveness of various lead testing strategies in the primary care setting. In a different study by Kemper et al,11 the most cost-effective lead screening program varied based on the prevalence of lead intoxication in the community. In higher-prevalence populations (generally urban), universal screening was the most cost-effective screening method.13 The Centers for Disease Control and Prevention defines a high-prevalence area as when the prevalence of elevated BLLs is at least 12%.14 In low- and medium-prevalence populations, targeted screening that used a combination of geographic risk stratification and lead risk assessment questionnaires with BLL testing following a positive initial screen was more cost-effective.13

If point-of-care testing is neither cost-effective nor time-effective in the ED, there may be other methods that could help to improve patient follow-up. A study by Polivka et al.15,16 suggested a greater likelihood of a child having BLL testing when the guardian was reminded through a letter, reminder card, or phone call. Patients seemed to prefer brochures or pamphlets.16 Other factors that have improved BLL testing rates include receiving easy-to-read informational materials as well as videos with lead poisoning education.15-17 Focus groups that looked at barriers to BLL testing showed that parents preferred to have all of their testing performed at the same facility and did not like to travel to multiple locations to have testing performed.18 These parents also stated that they were hesitant to have testing done because of the traumatizing nature of multiple blood tests and immunizations for children.19

When looking at the 74 patients with BLLs recorded at Peoria City/County or Tazewell County Health Department, 28 (37.8%) had BLLs drawn before their ED visit. This suggests that the parent or guardian who answered the questionnaire in the ED erroneously believed that the child had not been previously tested for lead intoxication. In a different study by Polivka et al.,15 parental reporting of prior lead testing was compared with Medicaid claims and blood lead surveillance data. They found that whereas 55.6% of respondents stated that the child had a BLL drawn, only 56.1% of these children actually had a record of a BLL, and of the 44.4% of respondents who claimed to not have had BLL testing, 22.9% had records of a prior BLL in the Medicaid or blood lead surveillance systems.15 Many respondents reported that they were confused and did not know what tests had been performed on their children during each visit to the doctor’s office. These findings emphasize the necessity for effective communication between physicians, nurses,
and health care staff and patients and caregivers. With different organizations providing health care to at-risk children, it can be confusing for parents or guardians to maintain children’s health records. In addition, with multiple access points for patients to receive health care interventions, universal access to a common database, such as the STELLAR system utilized in Illinois or a common electronic health record, would ensure that repetitive tests are not performed.

In our study, there were 4 patients (5.4%) who had a clinically significant BLL greater than 10 μg/dL. This is similar to a 1999 Illinois study, which demonstrated an elevated BLL prevalence of 7%.10 All 4 of these patients had a BLL drawn before the ED visit, suggesting that Peoria County’s “Elimination of Lead Poisoning” initiative is improving adequate screening practices.18 This is contradictory to what had been found by Kemper et al in Michigan, where only 60% of local health departments surveyed offered BLL testing, environmental investigation, and case management.19 Kemper15 suggests that budgetary limitations by state legislatures have been key in this lack of screening. In the Peoria area, the initiative has been funded through grant programs (Healthy Moms/Healthy Kids and Women, Infants, and Children Program) and state budget, but has also received much publicity through the local media outlets and housing authority.18 Rochester, NY, passed a similar initiative in 2005 looking to eliminate lead poisoning using a similar multifaceted approach as Peoria with success.20 The key to this program’s success despite budgetary limitations was attributed to a diverse community of child health advocates in nontraditional venues such as education, housing markets, and within the legal system.

The questionnaire used in the study may need to be reevaluated. In the study by Binns et al10 that looked at versions of the Illinois questionnaire, only 2 questions predicted if a child would have an elevated BLL: the year the home was built (before 1960) and if there was exposure to peeling or chipping paint within the home. This corresponds to the 2 most commonly positive questions on our risk assessment questionnaire: if the child lived in or visited a home built before 1978 and whether the child had renovation exposure in a house built before 1978. One question in our tool, about living near a factory where lead was used, had no affirmative responses. This question should have warranted some positive responses because of the close proximity of some large manufacturing plants and smelters in the area. The average sensitivity of similar risk assessment questionnaires is approximately 75%, whereas versions with a different subset of questions had a sensitivity nearing 90%.14 Because BLLs were not drawn on all children receiving the risk assessment questionnaire, it could not be evaluated for its sensitivity or specificity in our population. Further studies will need to be performed to determine the predictive value of each of these questions in an ED population.

A limiting factor to this study was the large proportion of our study population that did not receive the risk assessment questionnaire (2698/3513, 76.8%). When comparing this population to those who did receive the questionnaire, we found some major differences in their diagnoses, their insurance status, their mode of arrival to the ED, and whether they were admitted to the hospital after their presentation. This could suggest that the person giving the questionnaire canceled the order because of a severe illness or, less likely, that children with more severe illnesses are more likely to have been previously screened for lead intoxication. The abstracted electronic record did not contain documentation as to why the lead risk assessment questionnaire was not administered. In addition, children may have followed up with an established primary care physician or a health department outside the study area, as we were not able to access these records. This may have led to selection bias, falsely lowering the number of patients who completed follow-up after screening positive. However, in our community, most clinics and many primary care physicians refer patients to the health department for lead screening and environmental management. The data obtained for this study were obtained in a retrospective fashion and therefore suffer from the limitations intrinsic to that design, but a prospective study in the future could provide for better follow-up of patients. Finally, the children in this study, as well as the socioeconomic demographics of the setting, may not be representative of all populations presenting to an ED.

CONCLUSIONS

The use of a lead risk assessment questionnaire in an ED setting with subsequent discharge referral to the local health department for formal BLL screening was not an effective method in identifying children with potential lead intoxication. Point-of-care BLL testing within the ED would be more effective if there was a more operative communication modality in place between the ED and the health departments. Should a screening program continue, there should be an accountable party to ensure that follow-up occurs. Ideally, screening and follow-up would occur in the same place, which is why having the primary care setting or the county health department as the single location for screening and follow-up is ideal. The program would also focus on education for parents as it was suggested that parents and guardians do not fully understand the testing that their children undergo.

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The Characteristics and Outcomes of Foreign Body Ingestion and Aspiration in Children Due to Lodged Foreign Body in the Aerodigestive Tract: Erratum

In the article that appeared on page 53 of the January issue, an authors’ name was listed incorrectly as Mehmet Tahir Gökdemir. The correct spelling is Mehmet Tahir Gökdemir.

**REFERENCE**

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