

## **INTRODUCTION:**

Out of all the potentially toxic heavy metals, lead is easily one of the most prevalent and common environmental exposures in the United States (US). When considering the impact in the US, the Centers for Disease Control and Prevention (CDC) found that in 2006 alone, nearly 40,000 children under the age of 6 years old were screened and confirmed to have an elevated blood lead level of at least 10 µg/dL.<sup>1</sup> Illinois makes up nearly 10% of the national yearly cases and has the highest incidence of pediatric elevated lead levels in the country (Blood lead level  $\geq$  10µg/dL).<sup>1</sup> On a local level, Peoria County maintains one of the highest incidences of elevated blood lead levels in the state.<sup>1</sup>

Current state guidelines requires universal screening by every licensed physician and healthcare facility for children between 6 months and 6 years of age with blood lead level screening or through the use of a risk assessment questionnaire to determine high-risk populations followed by screening those in a high-risk category.<sup>2,3</sup> 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 blood lead levels with a corresponding negative predictive value of 99%.<sup>4</sup>

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 healthcare venues that may substitute as primary care for those patients lacking a medical home has not been studied. One such healthcare venue is the hospital emergency department (ED), as many underserved pediatric and adult patients utilize this location for both emergent illnesses as well as for primary care. These patients have a tendency to underutilize

primary care physicians due to many factors, including: being “fired” as patients from chronic absentee-ism 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.<sup>5</sup> 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.<sup>6,7</sup>

With the recommendation by the Illinois Department of Public Health (IDPH) that all physicians should be screening children for elevated blood lead levels, 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.<sup>8</sup> 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 of age. 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 use of this standardized, validated lead risk assessment questionnaire, with a subsequent discharge referral to the local health department for formal blood lead level screening, was an effective method for identifying high risk children that 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 7/2007 through 12/2007.

### Study Population

CHOI/SFMC is located in Peoria, Illinois, which has an urban population of 115,007 in 2010, and serves as the primary tertiary referral hospital for the surrounding six-county Central Illinois region. The tri-county area, consisting of Tazewell, Peoria and Fulton Counties, ranks fourth among Illinois metropolitan statistical areas (behind Chicago, East St. Louis and Rock Island) with over 350,000 residents. According to the 2010 Census, Peoria County has a population of 186,494, with more than 25% less than 18 years old. The City of Peoria encompasses a socioeconomically and ethnically diverse urban population comprised 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. 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. CHOI/SFMC admits over 5,000 children from 60 counties, and annually completes over 70,000 ED visits, of which 15,000 represent children < 18 years old (21%).

Subjects were identified using the electronic medical record and electronic order entry system utilized at OSF SFMC ED (EMSTAT; Allscripts Inc., Chicago, IL) and abstracted. Subjects were included if they had a primary residence in the two 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 healthcare provider, utilized the Women, Infants and Children (WIC) program or were involved in specialized sponsored daycare in which lead screening is mandated at enrollment (i.e. Illinois KidKare). 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 Illinois Department of Public Health (IDPH) 6 question survey recommended by the American Academy of Pediatrics for targeted lead screening.<sup>8</sup> 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).<sup>9</sup> 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 cancelling the screening questionnaire if the nature of the patient's illness or injuries were severe and a verbal screening would interfere with patient care (i.e. severe multisystem trauma). Subjects were deemed to have a positive response to the screening questionnaire if they answered any question "yes". Those children that 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 pre-treatment and subject demographic variables were abstracted to a separate spreadsheet (Microsoft Excel 2003, Microsoft Corporation, Seattle, WA). 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 blood lead level 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 D.C.). These variables included time from ED visit to presentation at the county health departments (separated as blood lead level before ED visit – as parents were

unaware that their child had been screened in the past, same day visit, 1 day -6 months and greater than 6 months), blood lead level recorded in the database (measured by venous draw and reported as  $\mu\text{g}/\text{dL}$ ) 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.<sup>10</sup>

### 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 v 14.0, SPSS Inc., Chicago, IL). Patients given the questionnaire were compared to those not given the questionnaire. Variables were compared using Pearson  $\chi^2$  test for categorical variables or  $t$  test for continuous variables. Both skewness and Levene's Test for Equality of Variance were inspected prior to using the  $t$ -test. All reported  $p$  values were 2-sided. A  $p$  value  $< 0.05$  was considered to indicate statistical significance. Individual County data was compared. Individual questions within the questionnaire were evaluated for correlation. Health Department follow-up data was also compared to questionnaire responses.

### **RESULTS:**

During the study months (7/2007 to 12/2007), 3513 eligible children from Peoria and Tazewell Counties were evaluated in the ED. Of those patients, 815 (23.2%) children received the risk assessment questionnaire. Of those children that received the questionnaire, 25.6% (209/815) had at least one positive response on the questionnaire and were referred for outpatient follow-up

(Figure 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 neurologic 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 to unscreened children ( $p = 0.003$ ). According to the most recent census data from 2000, when compared 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 one affirmative response to the lead screening questionnaire (71.8%, 150/209), while 23.4% (49/209) had two affirmative responses and 4.8% (10/209) had three 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 that screened positive on the questionnaire, 35.4% (74/209) had a blood lead level (BLL) drawn at either Peoria or Tazewell County Health Department and only 14.8% (31/209) followed up within six months of their ED visit. The remaining BLLs from the health departments were either done 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 six months from their ED visit (7.2%; 15/209). Of the 74 patients with BLLs drawn at either Peoria or Tazewell County Health Departments, four were found to have a BLL >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 blood lead levels.<sup>4,9</sup> 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 blood lead levels (BLL). In addition, those patients that had clinically elevated BLLs had received intervention prior to 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 time period previously established.<sup>10</sup> A study by Kemper et al. looked at the follow-up rate at local health departments after children had a documented elevated blood lead level in a primary care setting.<sup>10</sup> 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 Kemper's study 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 required 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 and weekends and contact information may be inaccurate. In addition, the children in Kemper's study had a documented elevated BLL, rather than the risk of one and may 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 BLL testing in the ED, there have been a few prior studies looking at other basic health screenings in the ED. Mandelblatt et al 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.<sup>11</sup> 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., 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.<sup>12</sup> The CDC defines a high-prevalence area as when the prevalence of elevated BLLs is at least 12%.<sup>13</sup> 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.<sup>12</sup>

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. suggested a greater likelihood of a child having BLL testing when the guardian was reminded through a letter, reminder card or phone call.<sup>14,15</sup> Patients seemed to prefer brochures or pamphlets.<sup>15</sup> Other factors that have improved BLL testing rates include receiving easy to read informational

materials as well as videos with lead poisoning education.<sup>14-16</sup> 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.<sup>16</sup> These parents also stated that they were hesitant to have testing done due to the traumatizing nature of multiple blood tests and immunizations for children.<sup>16</sup>

When looking at the 74 patients with BLLs recorded at Peoria City/County or Tazewell County Health Department, 28 (37.8%) had BLLs drawn prior to 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 different study by Polivka et al., parental reporting of prior lead testing was compared to Medicaid claims and blood lead surveillance data.<sup>14</sup> They found that while 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.<sup>14</sup> 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 healthcare staff and patients and caregivers. With different organizations providing healthcare to at-risk children, it can be confusing for a parents or guardians to maintain children's health records. In addition, with multiple access points for patients to receive healthcare 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 (5.4%) patients who had a clinically significant BLL greater than 10µg/dL. This is similar to a 1999 Illinois study which demonstrated an elevated blood lead level prevalence of 7%.<sup>9</sup> All 4 of these patients had a BLL drawn prior to the emergency department visit suggesting that Peoria County's 'Elimination of Lead Poisoning' initiative is improving adequate screening practices.<sup>17</sup> 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.<sup>18</sup> Kemper 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 WIC) and state budget, but has also received much publicity through the local media outlets and housing authority.<sup>17</sup> Rochester, NY passed a similar initiative in 2005 looking to eliminate lead poisoning utilizing a similar multifaceted approach as Peoria with success.<sup>19</sup> The key to this program's success despite budgetary limitations was attributed to a diverse community of child health advocates in non-traditional venues such as education, housing markets and within the legal system.

The questionnaire used in the study may need to be re-evaluated. In the study by Binns et al that looked at versions of the Illinois questionnaire, only two questions predicted if a child would have an elevated blood lead level: the year the home was built (before 1960) and if there was exposure to peeling or chipping paint within the home.<sup>9</sup> This corresponds to the two 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 due to the

close proximity of some large manufacturing plants and smelters in the area. The average sensitivity of similar risk assessment questionnaires are approximately 75% while versions with a different subset of questions had a sensitivity nearing 90%.<sup>9</sup> Since 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 that did receive the questionnaire, we found some major differences in their diagnoses, their insurance status, their mode of arrival to the ED and whether or not they were admitted to the hospital after their presentation. This could suggest that the person giving the questionnaire cancelled 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 of 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 that 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 was obtained in a retrospective fashion and therefore suffers 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 blood lead level screening was not an effective method in identifying children with potential lead intoxication. Point-of-care BLL testing within the emergency department 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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