Pediatric Lead Screening in the United States: A Comparative Analysis

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Project

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Abstract

The purpose of this project is identification of approaches to pediatric lead screening in the United States by each of the fifty states and evaluation of whether best practice is being utilized. Data was obtained from publicly available state based websites and interaction with state departments; there were no participants in this project. The data was compared and contrasted among each of the fifty states and against current screening recommendations from the Centers for Disease Control and Prevention [CDC]. Only one state, Delaware, has screening recommendations current with CDC standards. There is a large amount of variation between how state approaches pediatric lead screening. Several recommendations were proposed for the improvement of pediatric lead screening in the United States, including the following; all test results be reported in every state, states should assess need for screening universally versus screening Medicaid-eligible children only, states update their geographic risk areas yearly, screening recommendations be made available in a single area, and all questionnaire include questions about symptoms, lead sources, hand washing, and children with risk.

Introduction

Lead is a common metal found in the environment. In the United States an estimated 450,000 children aged one to five had a significant exposure to lead (Centers for Disease Control [CDC], 2012). Lead exposures, even to the extent of poisoning, have no hallmark presentation, which makes this diagnosis unclear; complaints are often vague, making identification challenging (Warniment, Tsang, & Glazka, 2010). There is no exposure level of lead that is without negative effects on children and all side effects from lead exposure are irreversible (Advisory Committee on Childhood Lead Poisoning Prevention, 2012).

Between 1960 and 1991, the Centers for Disease Control and Prevention (CDC) incrementally lowered the blood lead level of concern from 60µg/dL to 15µg/dL (2005). In 2005, the CDC set the new level of concern at 10 µg/dL. Although it was stated that adverse effects were being shown at levels lower than 10µg/dL, there was concern that categorizing these children as exposure cases would limit resources needed by children with higher levels (CDC, 2005). In their most recent report (2013), the CDC recommended no longer using the term "level of concern" and instead set the upper limit of normal to the 97.5th percentile, which is 5µg/dL for children aged one to five.

Lead based paint, dust contaminated with lead, water which runs through lead pipes, traditional folk medicines, jewelry, toys, and exposures to caregivers who work with lead are some of the most common ways children come into contact with lead (CDC, 2013). The most common route of lead exposure to children is ingestion (CDC, 2013; World Health Organization [WHO], 2010). Younger children are more frequently affected this way because of their instinct to put foreign objects, such as soil or lead-based paint, into their mouths (Howarth, 2012; United States Environmental Protection Agency [EPA], 2013; WHO, 2010). Eating wild game,

including fish, has also been significantly associated with an increase in blood lead levels (Iqbal, 2008; Watson & Avery, 2009). Children also absorb a greater percentage of the lead they ingest than their adult counterparts, causing higher exposures from the same amount of lead, though it is unclear why (Carlisle, Dowling, Siegel, & Alexeeff, 2009; Dikshith, 2013; EPA, 2013; Howarth, 2012; WHO, 2010). Other routes of exposure for children include inhalation and direct contact with skin to items containing lead (Dikshith, 2013; WHO, 2010).

Literature Review

Pediatric population screening practices

In 1991, the CDC suggested that all children aged 12-72 months be screened for lead exposure (CDC, 1997). In 1997, the CDC's data demonstrated that certain subpopulations of children, including minorities and the poor were at higher risk for lead exposures than other children. The CDC therefore recommended that children who receive public assistance, such as the Special Supplemental Nutrition Program for Women, Infants, and Children [WIC] or Medicaid, continue to receive universal lead screening, while other children be screened only if they met certain criteria (CDC, 1997). In 2000, the CDC's data indicated that 83% of children with blood lead levels $\geq$20 µg/dL were Medicaid-eligible, differentiating the designation between pediatric subpopulations as Medicaid-eligible and non-Medicaid-eligible.

In 2009, data from the CDC no longer demonstrated a disparity in risk for lead exposures between Medicaid-eligible and non-Medicaid-eligible children. The CDC suggested that states with lead screening plans in place should decide individually whether to continue to require universal screening of Medicaid-eligible children or to screen them the same way they do non-Medicaid-eligible children (CDC, 2009). They suggested that states without lead screening plans

in place continue to universally screen Medicaid-eligible children while continuing to acquire data assessing risk in their individual communities (CDC, 2009).

Effects of lead exposure

Gump et al. found that lead levels below 10µg/dL in children aged nine to eleven caused an inappropriate stress response resulting in negative cardiac outcomes, including reduced cardiac output, reduced stroke volume, and increased peripheral resistance (2011). Environmental exposures to lead at "low levels" caused arterial hypertension that manifests years after the exposure, making proof of causation from childhood exposures difficult; "little is known" about childhood exposures and future development of arterial hypertension (Vaziri, 2008, p. 455).

Lead exposures at levels below 10 have also been found to affect the renal endocrine systems as well. Fadrowski et al. found that children with lead levels below 10µg/dL had lower glomerular filtration rates (GFRs) and decreased kidney function following exposure (2010). Additionally, the damage occurs at a significantly lower level in children than it does in adults, though the effects are the same (Fels et al., 1998). Naicker et al. established that lead exposures, 99% of which were below 10µg/dL, led to delayed puberty in girls; these delays predisposed them to obesity, short stature, and psychological issues (2010).

Lead poisoning in children has been linked to brain damage, developmental delays, behavioral problems, violence, and death (Sanders et al., 2009). Jusko et al. (2007) established a negative correlation between intelligence and lead exposure and estimated that the difference in IQ from a lead exposure level between 5µg/dL to 9.9 µg/dL was 4.9 points. A five point shift downward on all children's IQ scores is estimated to cause a 57% increase in the amount of children designated with mild mental retardation and a 40% reduction in the number of children

who are considered "gifted" (Jusko et al., 2007). Gould (2009) estimated that loss of IQ from lead exposures and resultant need for special education, health care costs, and a loss of productivity will potentially cost the United States $192-$270 billion dollars.

Lead exposures below 10 µg/dL have also been associated with a reduction in reading and writing scores in children aged seven to eight (Chandramouli, Steer, Ellis, & Emond, 2009). Nigg et al. found lead exposure, as little as 0.73 µg/dL to 2.2 µg/dL in children aged six to seventeen, was associated with Attention Deficit Hyperactivity Disorder-combined type (2010). According to the Advisory Committee on Childhood Lead Poisoning Prevention (2012), there is no lead exposure level that does not cause cognitive defects in humans.

Risk assessment questionnaires

The CDC has been recommending the use of risk assessment questionnaires to screen children for lead exposures since 1997. The CDC (2009) proposed that each state become more aware of its' specific lead risks and produce guidelines that address these risks while incorporating the following criteria in all state risk assessment questionnaires:

- Children suspected by parent or provider to be at risk
- Child with a sibling or playmate who had an established exposure
- Child with recent immigration as an adoptee, immigrant, or refugee
- Child whose parent or caregiver works with lead
- Household use of traditional remedies, ethnic remedies, folk remedies, or imported cosmetics
- Children who routinely eat imported food carried from out of country
- Children who have been deemed at risk by the health department due to local risk factors including living in a high-risk area

In addition to the CDC, other advisory groups have given opinions on lead screening. The American Academy of Pediatrics Committee on Environmental Health supports pediatricians using local or state guidelines for screening children for lead exposures (2005). The US Preventative Task Force (USPSTF) also advises that providers follow local or state screening

policies (Rischitelli, Nygren, Bougatsos, Freeman, & Helfand, 2006). Regarding the use of lead risk assessment questionnaires, the USPSTF's latest standpoint states that they "may" lead to more appropriate screening (Rischitelli et al., 2006).

Purpose

At this time no state-by-state comparison of approaches to pediatric lead screening exists, nor does a comparison of whether each state's recommendations meet current CDC recommendations. The purpose of this project is to provide insight into current pediatric lead screening practices in all 50 United States. This is performed with the impetus of increasing awareness to health care providers and policy makers about how pediatric lead screening is currently being approached. Ideally, awareness of discrepancies between current guidelines and current practice will create opportunities for practice change that may better serve the pediatric population.

Nursing Significance

Due to the irreversible damage suffered by lead exposures and the often asymptomatic presentation in affected children, it is important for health care providers in every state to have screening protocols in place. Appropriate screening will accurately identify those who will benefit from lead screening and those who will not in an effort to provide timely interventions, limit negative outcomes, and best allocate resources to limit cost. The intent of this analysis is to provide health care providers, policy makers, and legislators with an overview of state-based pediatric lead screening practices and identify whether these approaches are meeting current CDC recommendations.

Methods

Data Collection

The project was approached through method of comparative analysis. A comparative analysis is a systematic approach that compares two or more systems, in this case pediatric lead screening approaches per state and CDC guidelines, in order to identify emerging trends and disparities. These findings were documented and placed into context.

All data were acquired from state-sponsored websites. Only data concerning children, defined by the age range of newborn to eighteen years old, were included. Data were obtained from all 50 states pertaining to the following:

- The threshold μg/dL level required for reporting
- The sub-populations of children required to be screened
- The availability of a lead risk assessment questionnaire
- The additional questions included in lead risk assessment

Data were organized by development of tables. The first table included screening information and the second recorded the individual risk assessment questions. Data were collected from August to October in 2014 and therefore any changes to screening approaches produced after this time were not included.

Data Analysis

After initial data collection, individual state information was compared and contrasted. Common themes and unique approaches were identified. The data were then compared to current recommendations put forth by the CDC, as described above.

Framework

The theory underlying this comparative analysis is the Social Ecological Model (SEM) as seen in Figure 1 (Coreil, 2010; McLeroy, Bibeau, Steckler, & Glanz, 1988). The SEM was adapted from a conceptual model originally created by Urie Bronfenbrenner (Bronfenbrenner,

1979). This model emphasizes multi-level approach to health promotion; in order to create positive changes in the individual there must also be changes in the surrounding environment, which include the individuals, relationships, communities, and society (McLeroy, Bibeau, Steckler, & Glanz, 1988).

Results

Data collection

Data were collected from the 47 states with available lead reporting databases. However, there were five states with differing levels of reporting requirements: Arkansas, Nevada, South Dakota, Montana and Louisiana. Arkansas had a lead level-reporting threshold available for providers, but nothing regarding populations to be screened or a questionnaire. Nevada and South Dakota had no information available pertaining to pediatric lead screening either on their website or upon calling their state department. Arkansas and Montana made no recommendations about lead screening beyond mandatory reporting. Louisiana had lead screening recommendations available, but were not posted onto a state run website. LA recommendations were received by email upon request and were then included in this project.

Navigating state websites in search of lead screening protocols seemed to have two extremes: either all information was presented in a clear, comprehensive manner in a single document or was spread out over several places. At times data were missing completely. The Louisiana Department of Health and Hospitals created a tool kit which was not posted to their website; a direct phone call was necessary to retrieve it.

The Delaware Health and Social Services has all of the necessary screening information available on their website, yet the risk assessment questionnaire, populations that need to be screened, and reporting thresholds are located in three separate places.

Reporting Thresholds

As seen in Table 1, the majority of states require that health care providers report all lead results, regardless of number, to their health department ($N = 39$). Nine states request that only levels over a certain number (5-25µg/dL) be reported. Arizona, Pennsylvania, and Virginia use twenty-five µg/dL or greater as a reporting threshold for specific subpopulations: children over sixteen, children under sixteen, and children over fifteen. All children in Alabama, Idaho, North Dakota, and Utah along with children under sixteen years in Arizona, children under six in Arkansas, and children under fifteen in Virginia must report at 10 µg/dL or greater. Arkansas, Montana, Nevada, South Dakota and Pennsylvania do not require any reporting of lead levels on the following subpopulations respectively: children over six, children over thirteen, all children, all children, and children over sixteen. While Montana has no mandatory reporting over age thirteen, for children less than thirteen all results five µg/dL or above must be reported.

Populations

Universal Screening

Universal screening (Table 1, column 3) of all children residing within the state at certain ages is recommended by fifteen states. Of these states, none utilized only universal screening; there was inclusion of at least one other identified population. Children who were not previously tested in a universal screening environment (Table 1, column 4) were tested by eleven states. This population was tested alongside the universal screening population the majority of the time ($N = 11$).

Children with Disabilities or Symptoms

There are several subpopulations of children (Table 1, column 5) who are at increased risk for lead exposures. Their risk is increased either due to their established disabilities and

subsequent behaviors or by the possibility that their current symptoms might be from current lead exposures. These subpopulations are the following: 1) children with unexplained illness 2) children who eat non-food substances 3) children with behavioral problems 4) children with developmental delays and 5) children with symptoms that could be from lead poisoning. Nine states ask about at least one of these subpopulations. The Oregon Health Authority recommends testing of several of these subpopulations, including children at any age when they have the following symptoms: history of foreign body ingestion, developmental delays, symptoms that could be caused by lead exposures such as seizures, or behavioral issues such as attention deficit (2009).

Children with Increased Risk

This population (Table 1, column 6) includes children with identified risk as well as those who self-identified as unknown or those whose risk status changed. Minnesota utilizes questions related to changing risk status. The Minnesota Department of Health requests that providers test children who have moved from a "major metropolitan area" or a foreign country within the last year to their state; these children may be living in a low risk area now but their past indicates risk (2011). Forty-three states test this population, which makes it the most screened of the ten populations.

Three of the states that screen this population do not utilize a risk assessment questionnaire. The Colorado Department of Public Health and Environment includes children with low-income, regardless of participation in publicly supported programs, and children who live in older homes that may or may not be undergoing renovation (2008). The South Carolina Department of Health and Environmental Control defers determination of risk to the health care provider's discretion, which is their only recommended approach to screening (n.d.). While the

Virginia Department of Health does not provide a questionnaire, their at risk groups are similar to those asked about in other states' risk questionnaires: older housing, friends or family with diagnosed lead poisoning, living with adults that work with lead, or living near an industry that releases lead (2013).

Participation in Public Programs

Children who participate in publicly supported programs (Table 1, column 7), most prevalently Medicaid, are tested by the majority of states ($N = 30$). This population is not screened alone, but rather included amongst other populations. Children who participate in publicly supported programs that were not previously tested (Table 1, column 8), were also included as a population to be tested. Twenty-four states require that these populations be tested concurrently. The remaining six states do not require a child to be tested if he/she missed the initial screening period.

Geographic High-Risk

Children who live in high-risk areas of the state (Table 1, column 9), defined by either specific zip codes or entire cities, are another population designated to be tested. Twenty states screen these children. Massachusetts, Minnesota, and Nebraska ask providers to check yearly for changes as they update risk areas with new data. Texas refers health care providers to the United States Census Bureau's website (n.d.), which shows children's risk by entering their physical address. The other sixteen states do not routinely provide updated risk areas to providers.

School Aged Children

Children entering school (Table 1, column 10) are another population that is being tested. They are the least screened of any population ($N = 4$). The Iowa Department of Public Health (n.d.) and Massachusetts Department of Public Health (2002) require proof of prior testing or

screening before a child enters kindergarten. The Delaware Department of Health and Social Services require children entering any of the following to be tested: kindergarten, preschool, childcare facility, a private nursery or a public nursery (n.d.). The Maryland Department of Health and Mental Hygiene requires screening for children entering the following: first grade, kindergarten, or pre-kindergarten (2004).

Parent or Provider Suspicion

Children whose parents have requested a blood test or with health care provider suspicion (Table 1, column 11) make up another population. Of the nine states that screen them, five require testing only with parental request. The other four states require testing with either parental request or provider suspicion.

Additional Risk Groups

Immigrants, foreign adoptees, refuge children, children of migrant workers, or children in foster care (Table 1, column 12) are the last designated population and are screened by eight states. The Vermont Department of Health is the only state that specifically asks about children whose parents are migrant workers (n.d.). The Colorado Department of Public Health and Environment (2008) only screens refugees, while seven other states screen two or more of the above mentioned children.

CDC Risk Questionnaire Recommendations

Of the thirty-nine states that provide lead risk questionnaires, only one, Delaware, asks about all of the seven recommended CDC criteria discussed previously (Delaware Health and Social Services, n.d.). All states ask about at least one of the recommended criteria. The most utilized criterion from the CDC's recommendation list asks whether a child has a parent or caregiver who works with lead; thirty-three states ask about this. The least utilized criterion

asked about is whether the child is suspected by the parent or provider to be at risk for lead exposure; five states included it.

Risk Assessment Questionnaires

A total of forty-five different questions were identified as being used in risk assessment questionnaires available in the United States (see Table 2). The most common question is whether the child lives in a home or frequently visits a building that is or has been remodeled or renovated (36 states) Seventeen of the questions were identified by individual states

Several themes appeared, including: 1) questions about children with current signs or symptoms of possible lead poisoning and children with established exposures, 2) oral sources that might introduce lead, 3) housing questions, 4) risk in surrounding environment, and 5) other established lead sources both specific to the region and universal. These themes were identified by the researcher and used to organize the data.

Signs or symptoms and established exposures

Three questions (8, 38, and 42) address signs or symptoms of possible lead poisoning and established exposure. Five states asked about whether the child has had an elevated blood level in the past. Two states asked generally about symptoms of lead poisoning. Two other states asked more specifically about delayed development, behavioral disabilities, or learning disabilities. The Wyoming Department of Health was the only state to ask more than one of these questions; they used both 8 and 42 on their questionnaire (2013).

Oral Sources of Exposure

Eleven of the questions screen children for interaction with oral sources of lead. They include questions 6, 20, 26, 27, 28, 29, 30, 31, 33, 39, and 40. Both questions 20 and 26 are the most used, with fifteen states including each of them. The Louisiana Department of Health and

Hospitals is the only state to ask question 29, which addresses whether children's hands are washed before they eat (n.d.). Two states, the State of Alaska Department of Health and Social Services (2013) and North Dakota Department of Health (n.d.), ask about children eating wild game, which has been established to increase blood lead levels (Iqbal, 2008; Watson & Avery, 2009).

Housing

Seven questions ask questions about housing, including 11, 12, 13, 14, 15, 36, and 37. Thirty-one states asked a question about living in or visiting an older building (question 11). A question about whether these homes have been renovated either recently or in the recent past (question 13) was asked by thirty-six states. Questions 12 and 14 rephrase questions 11 and 13, asking instead if the child has ever lived in these conditions. These are both unpopular questions, with only one state asking each. Sixteen states ask question 15, which inquires specifically about peeling or chipping paint in older buildings.

Environment

Risk in the surrounding environment is addressed by questions 1, 2, 3, 7, 9, 10, 21, 22, 23, 24, 25, 32, 34, 43, and 45, with the first four being CDC recommended questions. Thirty-one states ask question 2, whether the child has a sibling or playmate with lead exposure, and fifteen states ask question 10, whether any relatives or members of the same household have been exposed to lead. Nine states ask question 23, which asks whether the child has lived or traveled out of the United States.

Other Sources

Lastly, there are eight questions about other established lead sources; 4,5,16, 17, 18, 19, 41, and 44. Sixteen states ask about living near industries likely to release lead. Four states

included a question about children playing in loose soil. The Tennessee Department of Health is the only state to ask a question about whether a home has lead pipes (n.d.).

Discussion/Recommendations

The CDC has established that there is no lead level of exposure to children that is without ill effects (2009). However, nine states still ask providers to report only over a certain level and two states have no mandatory reporting. Having access to all test results, regardless of negative or positive, is critical for producing accurate screening recommendations. Test results can be correlated with risk questionnaires to determine which questions predict true risk and which are unnecessary, finely tuning these instruments for providers. It allows each state to discover which current geographic areas are high risk, allowing for timely intervention to eliminate future exposure and accurate identification of children who should be screened. All of this information assists in developing accurate screening recommendations that increase the provider's ability to provide appropriate care. For these reasons, it is recommended by the author that all test results, whether positive or negative for lead exposures, should be reported and evaluated by every state. Costs to states will vary depending on available resources, testing materials, and testing procedures. Additional costs exist for those states that are not following current CDC guidelines, and also for states that need to evaluate their geographic risk. Cost to the provider would be minimal, especially if submission can be made electronically.

The CDC recommends that all states without a lead screening plan in place universally screen Medicaid-eligible children while acquiring data in order to assess risk in their communities (2009). Arkansas, Montana, Nevada, and South Dakota have no lead screening plan and none of them universally screen Medicaid-eligible children. Arkansas and Montana require providers to report lead results, though not universally, while Nevada and South Dakota do not

require reporting. It is recommended by the author that all four states universally screen Medicaid-eligible children, in accordance with current CDC recommendation. Also, the author recommends that all lead results be reported to their state departments. This will increase each state's data about lead exposures in their state.

Since 2009, the CDC established there is no longer a disparity between lead risk in Medicaid-eligible and non-Medicaid-eligible children and suggested that each state decide whether to continue with targeted Medicaid screening or change to universal screening. At this time, thirty states screen Medicaid-eligible children, fifteen states screen universally, and four states (Delaware, Kansas, North Carolina, and Pennsylvania) screen both. If the twenty-six states that screen only Medicaid-eligible children have not considered changing to a universal approach they should assess their risks, as the CDC data implies they might be missing lead positive non-Medicaid-eligible children.

The population that includes children with increased risk and children with symptoms is only tested by nine states. This is a very reasonable group to inquire about. The children with symptoms consistent with lead exposure could easily be overlooked due to the lack of hallmark symptoms. More importantly, lead exposure requires early intervention in order to limit negative, irreversible outcomes. Consequently, it is recommended that all states should consider inclusion of this population.

The South Carolina Department of Health and Environmental Control defer determining lead risk to the health care provider's discretion (n.d.). They provide neither a risk assessment questionnaire nor any other recommendations for populations that should be tested. They do require that all results of lead tests be reported, which gives them information about risk in the state. Health care providers would benefit from the South Carolina Department of Health and

Environment using this data to suggest targeted screening populations in order to best intervene and help children residing there. It is recommended that the South Carolina Department of Health and Environment consider evaluating their lab results and work on creating more targeted screening for their state.

Of the children who live in high-risk areas, only three states have declared they update their high-risk areas yearly (Massachusetts, Missouri, Nebraska). While other states may be also updating their targeted areas, they have not made it clear to providers where to access this information. It is recommended that all states with data collection capabilities supply providers with a list of updated risk areas yearly. This will update providers to emerging areas of risk, which ensures testing, and stop unnecessary testing in areas that have eliminated lead in the environment. It should be clear to providers when this list will be updated and where to access it.

In the literature review, it was established that most lead exposures come from lead based paint, dust contaminated with lead, water which runs through lead pipes, traditional folk medicines, jewelry, toys, and exposures to caregivers who work with lead (CDC, 2013). All of these exposure types are mentioned in some way by a risk assessment question. However, no states asked questions about all of these sources. It is recommended that all states include a risk assessment question asking about all of these common sources in order to truly assess a child's risk.

Many states with risk questionnaires include questions about populations they have already asked providers to screen. For example, California, Delaware, and North Carolina ask all providers to test children who have recently immigrated and also ask, "Has your child recently immigrated?" on their risk assessment questionnaire. This redundancy makes sense, as it is one more trigger to remind the provider that a certain population is at increased risk. However, there

were several states that don't take advantage of this reiteration. Nine other states ask the same question, ensuring that these children will be tested, but do not identify children who have immigrated as a population that needs to be screened. Florida requires that this population be tested but doesn't include a screening question on their risk assessment questionnaire. It is recommended that states ensure the populations they deem at risk be included in the risk questionnaire screening questions as an additional safeguard to ensure adequate lead screening.

There are several questions that address universal or widespread risk factors but are asked by a limited number of states. For example, question 34 asks whether a child participates in cultural practices that may use lead and is only asked by the Michigan Department of Community Health (2009). This question would be appropriate to use in any state, as cultural and recreational practices in our nation are varied. It also opens up a conversation between the parents and providers, allowing parents to discuss cultural practices and to consider lead risks they might not have thought about otherwise. It is recommended that each state review other lead risk assessment questionnaires and consider inclusion questions that pertain to their pediatric populations.

The Louisiana Department of Health is the only department to ask whether parents wash children's hands before they eat. This is an intriguing question, as it has been established that children are at higher risk for lead exposures secondary to handling things contaminated with lead, (such as soil), then putting their hands in their mouths. The CDC states that washing a child's hands before eating assists in preventing lead exposure (2013). It is recommended that states consider adding a question about hand washing into their questionnaires or ensure that information about decreasing lead risk through hand washing is available to providers and the general public.

Both the State of Alaska Department of Health and Human Services (2013) and the North Dakota Department of Health (n.d.) include a question about children eating wild game, as it has been established that wild game increases blood lead levels (Iqbal, 2008; Watson & Avery, 2009). This question assists parents in both recognizing that wild game poses a risk of lead exposure to their families and also allows them to acknowledge whether they hunt or not to the provider, so that their risk can be assessed. This would be a good question for any state with high subsistence rates or large quantities of hunters to include.

Five states ask whether the child has had a history of elevated blood lead levels in the past. This is a great question, especially for children joining a new practice, as it identifies children who have established sources of lead in their environment. This question also clues in providers to ask about whether the lead source was identified, if there are ongoing risks, whether the child has symptoms, and also whether any existing siblings have been tested or need testing. It is recommended that other states consider inclusion of this question.

Limitations/Future Research

The largest limitation to this study lies in the risk factor questionnaire section. Without knowing how strongly each question correlates with true lead exposure risk, it is difficult to make recommendations about which questions should be utilized by each state and which are not appropriate questions. Future research might be done to evaluate all questions asked in current risk questionnaires. Comparing data on actual sources of exposures against local and national risk questions to establish a risk correlation would greatly improve risk questionnaires in general. Additionally, continued and systematic collection of data on pediatric lead exposures would be of benefit.

Conclusion

Based upon the identification of weaknesses and unique approaches to pediatric lead screening currently being utilized in the United States, this study has given several recommendations with the aims of improving current practices. Utilizing the SEM framework, this project proposed change on many levels. This was done with the understanding that in order to create positive changes in the individual, there must be changes in the surrounding environment.

On a policy level, the states with screening protocols that are not compliant with CDC recommendations or which do not provide clear, evidence based screening strategies in a single document accessible to providers can improve upon current policies. On an organizational level, clinics and hospitals are encouraged to implement policies that support their providers by evaluating whether their state's recommendations are best practice. On an interpersonal level, nurse practitioners as well as other health care providers will be able to analyze information presented in this project and current recommendations from their state to determine how they will provide accurate screening approaches to their patients.

Recommendations made by this project can be considered for implementation by the nurse practitioner in order to supplement their own state's recommendations as they find necessary. This will assist the nurse practitioner and other health care providers in their ability to provide appropriate care for their pediatric patients. This multilevel approach to health care promotion can be an impetus to provide the best screening possible, ensuring healthier children in the United States.

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Appendix

Table 1

Screening Approaches in the Fifty States

Column 1: State	Column 2: Reporting Threshold for Providers (µg/dL)	Column 3: All children at defined ages	Column 4: All children not previously tested at defined ages	Column 5: Any child with symptoms of possible lead poisoning, unexplained illness, foreign substance ingestion, behavioral problems, or developmental delays	Column 6: Children with increased risk, positive answers on questionnaire, or with changes in risk status	Column 7: Children that participate in publicly supported programs at defined ages	Column 8: Children that participate in publicly supported programs and were not tested at defined ages	Column 9: Children that live in high risk areas at defined ages	Column 10: Children entering public school at defined ages	Column 11: All children whose parents have requested a screen or with provider suspicion	Column 12: All foreign adoptees, immigrants, refugees, children of migrant workers, or in foster care	Column 13: Use of risk assessment questionnaire?
Alabama	>10	X	X	X	X							X
Alaska	All				X							X
Arizona	<16: >10 >16: >25				X	X	X	X				X
Arkansas**	<6: >10 >6: none											
California	All				X	X	X			X	X	X
Colorado	All				X	X	X	X			X	
Connecticut	All	X	X	X	X							X
Delaware	All	X			X	X		X	X	X	X	X
Florida	All			X	X	X	X	X			X	X
Georgia	All				X	X	X	X				X
Hawaii	All				X	X	X					X
Idaho	≥ 10					X	X					
Illinois	All			X	X	X	X	X				X

Column 1: State	Column 2: Reporting Threshold for Providers (µg/dL)	Column 3: All children at defined ages	Column 4: All children not previously tested at defined ages	Column 5: Any child with symptoms of possible lead poisoning, unexplained illness, foreign substance ingestion, behavioral problems, or developmental delays	Column 6: Children with increased risk, positive answers on questionnaire, or with changes in risk status	Column 7: Children that participate in publicly supported programs at defined ages	Column 8: Children that participate in publicly supported programs and were not tested at defined ages	Column 9: Children that live in high risk areas at defined ages	Column 10: Children entering public school at defined ages	Column 11: All children whose parents have requested a screen or with provider suspicion	Column 12: All foreign adoptees, immigrants, refugees, children of migrant workers, or in foster care	Column 13: Use of risk assessment questionnaire ?
Indiana	All	X	X		X							X
Iowa	All	X	X		X				X			X
Kansas	All	X			X	X	X					X
Kentucky	All				X	X		X				X
Louisiana	All	X	X		X							X
Maine	All			X	X	X						X
Maryland	All				X	X	X	X	X			X
Massachusetts	All	X						X	X			X
Michigan	All				X	X	X	X				X
Minnesota	All				X	X	X	X		X		X
Mississippi	All			X	X	X	X					X
Missouri	All				X	X	X	X				X
Montana**	<13: ≥ 5 >13: none											
Nebraska	All				X	X	X	X				X
Nevada*												
New Hampshire	All				X	X	X	X				X

New Jersey	All	X	X		X							X
New Mexico	All				X	X	X			X		X
Column 1: State	Column 2: Reporting Threshold for Providers (µg/dL)	Column 3: All children at defined ages	Column 4: All children not previously tested at defined ages	Column 5: Any child with symptoms of possible lead poisoning, unexplained illness, foreign substance ingestion, behavioral problems, or developmental delays	Column 6: Children with increased risk, positive answers on questionnaire, or with changes in risk status	Column 7: Children that participate in publicly supported programs at defined ages	Column 8: Children that participate in publicly supported programs and were not tested at defined ages	Column 9: Children that live in high risk areas at defined ages	Column 10: Children entering public school at defined ages	Column 11: All children whose parents have requested a screen or with provider suspicion	Column 12: All foreign adoptees, immigrants, refugees, children of migrant workers, or in foster care	Column 13: Use of risk assessment questionnaire ?
New York	All	X			X							X
North Carolina	All	X	X		X	X		X			X	X
North Dakota	>10				X	X	X					X
Ohio	All				X	X		X				X
Oklahoma	All				X	X						X
Oregon	All			X	X							X
Pennsylvania	<16: ≥ 25 >16: none	X	X			X	X					
Rhode Island	All	X	X		X							X
South Carolina	All				X							
South Dakota*												
Tennessee	All	X	X		X					X		X
Texas	All				X	X	X	X		X		X
Utah	≥ 10				X			X		X		X
Vermont	All	X	X	X							X	
Virginia	<15: ≥ 10 >15: ≥ 25				X	X	X	X		X		
Washington	All			X	X					X	X	

West Virginia	All				X	X	X					
Wisconsin	All				X	X	X	X				X
Column 1: State	Column 2: Reporting Threshold for Providers (µg/dL)	Column 3: All children at defined ages	Column 4: All children not previously tested at defined ages	Column 5: Any child with symptoms of possible lead poisoning, unexplained illness, foreign substance ingestion, behavioral problems, or developmental delays	Column 6: Children with increased risk, positive answers on questionnaire, or with changes in risk status	Column 7: Children that participate in publicly supported programs at defined ages	Column 8: Children that participate in publicly supported programs and were not tested at defined ages	Column 9: Children that live in high risk areas at defined ages	Column 10: Children entering public school at defined ages	Column 11: All children whose parents have requested a screen or with provider suspicion	Column 12: All foreign adoptees, immigrants, refugees, children of migrant workers, or in foster care	Column 13: Use of risk assessment questionnaire ?
Wyoming	All				X	X	X					X

*State has no protocols for pediatric lead screening per their Department of Health

**State refers providers to the CDC's protocols, has no state protocol

Table 2

Questions Included in Risk Assessment Questionnaires by Participating States

		AL	AK	AZ	CA	CT	DE	FL	GA	HI	IL	IN	IA	KS	KY	LA	MA	MD	ME	MI	MN	MS	MO	NC	ND	NE	NH	NJ	NM	NY	OH	OK	OR	RI	TN	TX	UT	VA	WI	WY
1	Do you suspect that your child is at risk?	X			X		X																															X		X
2	Does your child have a sibling or friend who has been exposed to lead or diagnosed with lead poisoning?	X		X		X	X		X	X	X	X	X		X		X			X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
3	Had your child recently immigrated as an adoptee, immigrant, or refugee?	X	X		X		X				X	X								X				X		X						X			X		X		
4	Do any adults that routinely interact with your child come into contact with lead?	X	X	X		X	X	X	X	X	X	X	X	X	X	X		X	X	X		X	X		X	X	X	X	X	X	X	X	X	X	X		X		X
5	Does your household contain traditional, ethnic, folk remedies, or cosmetics?	X	X	X		X	X	X	X			X	X		X	X				X		X	X		X	X	X		X	X		X	X		X	X				X
6	Does your child routinely eat food known to have lead or was carried/ informally imported from another country?	X	X	X			X	X					X		X	X									X				X	X						X				X
7	Do you live in or frequently visit area deemed high-risk by the health department?						X				X									X			X								X	X								

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8	Has your child had an elevated blood level in the past?									X											X						X	X												X
9	Does your child receive benefits from a publicly supported program (i.e. Medicaid, Head Start)?	X									X								X	X				X			X		X		X	X	X				X	X	X
10	Has anyone who lives in the same house or is related to your child had elevated blood lead levels?		X			X								X	X			X			X			X	X					X		X	X	X		X		X		X
11	Does your child live in or visit a home or building built before 1950/1960/1978?	X	X	X		X	X	X	X	X	X	X	X	X		X		X	X	X	X	X	X	X		X	X		X		X		X		X	X	X	X	X	X
12	Has your child ever lived in a home built before 1950?																																						X	
13	Does your child live in or visit a home or building that is or was undergoing renovation or remodeling?	X	X	X	X			X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
14	Has your child ever lived in a house undergoing remodeling?																																						X	

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15	Have you noticed any peeling or chipping paint in or around the pre-1960/1978 house or building that your child has lived in or regularly visited?				X								X		X	X	X	X			X	X	X		X			X		X	X	X		X					
16	Does your child live near industries likely to release lead?	X		X			X	X	X		X		X	X									X				X		X	X				X	X			X	
17	Does your child live by or play near a busy road?							X							X							X					X		X	X					X				
18	Does your child play in loose soil?			X				X								X							X																
19	Does your child live near or play on tailings from mining or milling operations?																																				X			
20	Does your child eat or drink from imported pottery or imported ceramic cookware?		X	X				X		X				X	X	X											X		X	X		X	X		X	X				X
21	Is the child in foster care?							X												X						X													
22	Is your child a member of a minority group?											X																												
23	Has your child visited or lived in another country?		X	X				X			X		X														X			X			X						X
24	Are you requesting a lead exposure test?				X																																	X		
25	Have you had a change in circumstance has put your child at risk for lead exposure?				X																																			X

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26	Does your child eat or chew on non-food substances?		X	X				X	X	X			X			X		X				X	X				X		X	X					X	X				
27	Does the child have a sibling with excessive mouthing behavior?																																							X
28	Does your child eat or drink from leaded crystal or pewter dishes?							X						X		X														X			X		X					
29	Are the child's hands washed before meals and snacks?															X																								
30	Does your child drink well water?																					X																		
31	Does your child eat wild game?		X																						X															
32	Have you recently moved?																										X													
33	Does your child chew on our mouth jewelry or toys from vending machines?																															X								
34	Do you participate in any cultural practices that may use lead?																			X																				
35	Does your child participate in hobbies that might expose them to lead?														X																									
36	Does your home or a building your child visits frequently have plastic or vinyl mini-blinds?							X								X						X		X	X				X			X			X					

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37	Does your child live in a house/building built before 1978 that has water damage?																				X																			
38	Has your child had any symptoms consistent with lead poisoning?						X	X																																
39	Does your family have a catchment water system?									X																														
40	Do you use hot tap water for cooking or drinking?																										X													
41	Are painted materials or unusual materials ever burned in a household fireplace?															X																								
42	Do you have any concerns for or is there evidence of delayed development, behavioral disabilities, or learning disabilities?																																X							X
43	Have you ever been told your child has low iron or anemia?																										X								X					
44	Does your home have lead pipes or copper pipes with lead joints?																																		X					
45	Are the child's parents migrant farm workers?																																							X

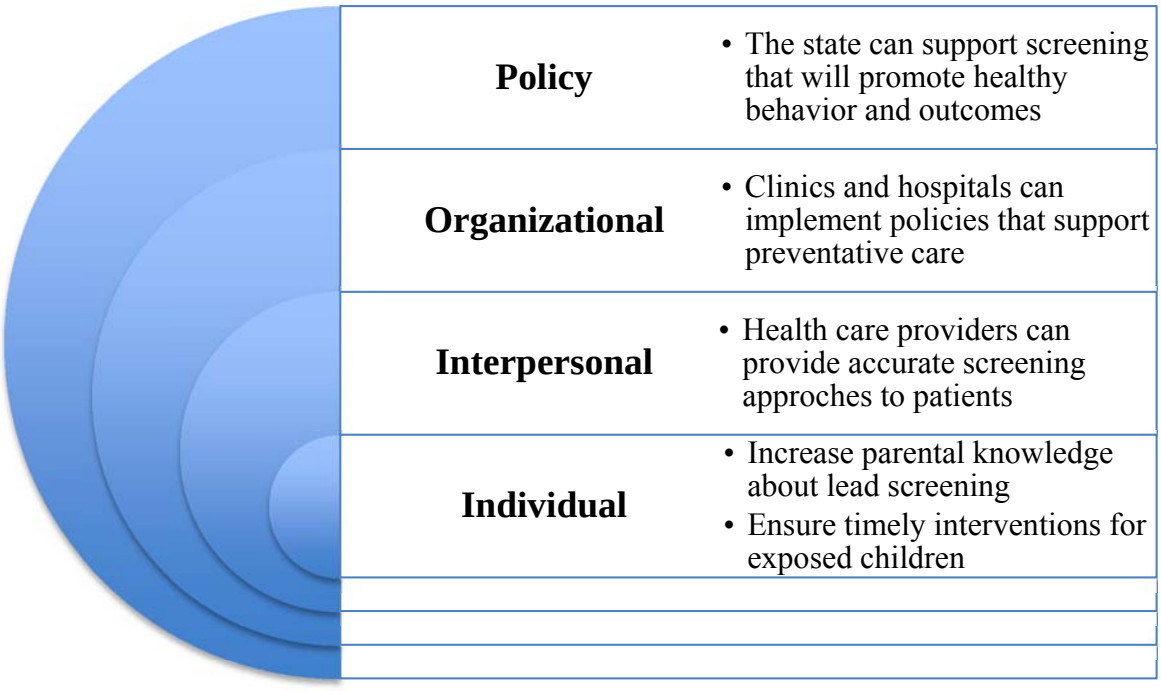

Figure 1. Framework for this project based upon the Social Ecological Model. It emphasizes that change happens to the individual when their surrounding environment also changes.