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Lead Poisoning Risk Determination in a Rural Setting

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TITLE: Lead Poisoning Risk Determination in a Rural Setting

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ABSTRACT: Objectives. To determine the prevalence of elevated blood lead levels among children living in a rural area and to determine the effectiveness of the Centers for Disease Control and Prevention (CDC) Lead Risk Assessment Questionnaire and additional questionnaire items in correctly identifying rural children having elevated blood lead levels.

Research Design. Comparison of results of a questionnaire that is intended to identify children as being at low or high risk for lead poisoning with children's blood lead levels.

Setting. The three practice sites of the only pediatric group in a rural county of upstate New York.

Patients. A consecutive sample of 705 children ages 6 to 72 months who were seen for health supervision visits between June and September 1993.

Results. Sixty-nine percent of the children were considered to be at high risk for lead poisoning by the CDC questionnaire. Overall, 8.4% of the children in the study had blood lead levels of 10 [mu] g/dL (0.48 [mu] mol/L) or higher, and 2.1% had blood lead levels of 15 [mu] g/dL (0.72 [mu] mol/L) or higher. No significant difference was noted between the percentages of high- and low-risk children who had elevated blood lead levels. To devise a more effective lead risk assessment tool for children in this setting, the two items from the CDC questionnaire and the two additional items that had the greatest predictive utility were combined to form a short alternative questionnaire. The alternative questionnaire thus consisted of items concerning whether the child has a sibling or playmate with lead poisoning, whether the child lives near an industry that potentially may release lead, whether the child lives in rented or owner-occupied housing, and whether the child has a parent who is a **migrant** farm worker. Children categorized as high risk with the alternative questionnaire were much more likely to have elevated blood lead levels than those who were categorized as low risk. The alternative questionnaire was very effective in correctly identifying children with elevated blood lead

levels. Eighty-eight percent of children having blood lead levels of 10 [mu] g/dL or higher and 100% of children having blood lead levels of 15 [mu] g/dL or higher were classified as high risk by the questionnaire. Children classified as low risk were very unlikely to have elevated blood lead levels; 98% of low-risk children had blood lead levels of less than 10 [mu] g/dL, and 100% had blood lead levels of less than 15 [mu] g/dL.

Conclusions. These results suggest that the CDC lead risk assessment questionnaire is of limited benefit in identifying rural children with blood lead levels 10 [mu] g/dL or higher or 15 [mu] g/dL or higher. An alternative questionnaire, however, seems to have marked clinical utility for identifying rural children with elevated blood lead levels.

[lead, screening, risk determination, rural.]

TEXT:

ABBREVIATIONS. CDC, Centers for Disease Control and Prevention; RR, relative risk.

In 1991, the Centers for Disease Control and Prevention (CDC) [n1] established revised guidelines for lead screening and intervention. These guidelines call for assessment of the risk of lead exposure by use of a five-item questionnaire at every regular office visit for all children in the United States ages 6 months to 6 years. Children determined to be at high risk are then to be screened frequently for lead.

Several studies have evaluated the effectiveness of the CDC questionnaire. [n2-n6] These studies were undertaken in urban and suburban practice settings and in communities that varied widely with regard to the prevalence of children in their populations who had elevated blood lead levels. Nevertheless, the sensitivity of the questionnaire was remarkably constant in all of the studies, ranging from 65% to 77%, whereas the negative predictive value (the measure of the proportion of children considered to be at low risk by the questionnaire who indeed had blood lead levels of less than 10 [mu] g/dL [0.48 [mu] mol/L]) ranged from 82% to more than 99%. However, none of the studies evaluating the CDC questionnaire were undertaken in a rural setting. Information is thus lacking about the effectiveness of this questionnaire in correctly determining the risk of lead poisoning among children living in rural areas. [n7-n10] The present study was conducted to determine the prevalence of elevated lead levels among children living in rural communities, to test the CDC risk assessment questionnaire in a rural setting, and to determine whether an alternative questionnaire containing both population-specific and general risk assessment items may be more effective than the CDC questionnaire in correctly identifying rural children with elevated blood lead levels.

METHODS

To test the effectiveness of the CDC's risk assessment questionnaire in correctly identifying children with elevated blood lead levels, we decided to compare risk categorization as determined by the questionnaire to actual lead screening results using [chi]<2> analysis to determine statistical significance. The protocol for this study was approved by the Research Subjects Review Board of the University of Rochester.

A 13-item questionnaire (Table 1) was completed by the parents of all children ages 6 to 72 months who had health supervision visits between June and September 1993 at any of the three practice sites of the only pediatric practice in Wayne County, NY. Wayne County is a predominantly rural county in upstate New York with a 1990 population of 85000.

TABLE 1. Items Used to Determine Risk of Lead Exposure

1. Does your child live in or regularly visit a house built before 1960, which has peeling or chipping paint?
Yes No Unsure
2. Did your child ever previously live in a house built before 1960, which had peeling or

chipping paint?
Yes No Unsure
3. Does your child live in or regularly visit a house built before 1960, which has recent, ongoing, or planned renovations or remodeling?
Yes No Unsure
4. Does your child have a brother, sister, housemate, or playmate who is followed or treated for lead poisoning (that is, having a blood lead level of 15 or higher)?
Yes No Unsure
5. Does your child live with an adult whose job or hobby involves exposure to lead?
Yes No Unsure
6. Does your child live near a lead smelter, battery recycling plant, or any other type of industry that is likely to release lead?
Yes No Unsure
7. Where does your child live?
In a Town On a Farm
Outside of a town but not on a farm
8. Does anyone living in your home operate farm equipment?
Yes No
9. Do you rent or own your home?
Rent Own
10. How many times has your family moved since your child was 6 months old?
Once Twice Three times More than three times
Never moved
11. Are you or your child's other parent **migrant** farm workers?
Yes No
12. Has your child ever lived outside of the United States?
Yes No
13. Does your child regularly attend day care or stay at a babysitter's home?
Yes No

The questionnaire, which was available in English and Spanish, included the five risk assessment questions suggested by the CDC, as well as several additional items that were also thought to be of potential benefit in correctly identifying children who were at particular risk for lead exposure. Some of the questions were specific for children living in rural areas. Children for whom any of the five CDC risk determination questions were answered "yes" were considered to be at high risk for lead exposure, and hence, for lead poisoning according to CDC criteria. Those children for whom all five questions were answered "no" were presumed to be at low risk. Risk assessment requires determining whether children are at high or low risk for lead exposure. Therefore, in instances when an equivocal response was given to one of the five CDC questions, the child was also considered to be at high risk.

After their parents completed the written risk assessment questionnaire, all children included in the study, except the 28 children who had been screened for lead within the previous 3 months, were sent to a hospital phlebotomy department, where an attempt was made to obtain venous blood samples for lead assays. If a venous blood specimen could not be obtained, a capillary blood specimen was sent instead. All samples were run by atomic absorption spectrophotometry at the same state-licensed outpatient laboratory.

The Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL) and Epi Info (CDC, Atlanta, GA; World Health Organization, Geneva, Switzerland) were used for analysis of the data. Relative risks (RRs) were determined, and [chi]<2> tests were used for significance testing.

Associations between responses to individual questionnaire items and blood lead levels were determined. The additional questions that were the most highly associated with elevated blood lead levels were combined with the items from the CDC questionnaire that had the most significant associations with elevated blood lead levels to form the alternative questionnaire. The effectiveness of the CDC and alternative questionnaires in accurately identifying children

with elevated blood lead levels was then determined by separately comparing the proportions of children with elevated blood lead levels among those who had been categorized as high or low risk by each questionnaire and by calculating the sensitivities and the negative predictive values of the questionnaires.

RESULTS

Seven hundred eleven children were initially enrolled in the study. Six children were subsequently dropped from the study, including one whose parent declined to complete the risk assessment questionnaire and five who did not have blood drawn for lead assays. Therefore, data from 705 children were analyzed. In more than 94% of cases, the blood lead assays were obtained by venipuncture. Overall, 8.4% of the children had blood lead levels of 10 [mu] g/dL (0.48 [mu] mol/L) or higher; 2.1% had blood lead levels of 15 [mu] g/dL (0.72 [mu] mol/L) or higher; and 1.0% had blood lead levels of 20 [mu] g/dL (0.96 [mu] mol/L) or higher. Ninety-two percent of the elevated blood lead levels were from specimens obtained by venipuncture. The age distribution of children having elevated blood lead levels is illustrated in the Figure. Blood lead levels of 15 [mu] g/dL or higher were primarily concentrated among children ages 17 to 34 months. All of the children whose blood lead levels were 20 [mu] g/dL or higher were between 11 and 34 months of age.

Table 2 lists the responses to each of the items on the risk assessment questionnaire. Parental responses to the five questionnaire items suggested by the CDC indicate that as many as 50% of the children in the study lived in homes built before 1960 that have peeling or chipping paint, and as many as 44% lived in homes built before 1960 with recent or planned renovations. These proportions were especially high because many parents, particularly those who rent, were unsure when their homes had been built and thus had difficulty answering these questions. There were relatively few children who had friends or siblings with lead levels of 15 [mu] g/dL (0.72 [mu] mol/L) or higher; few children lived with adults having jobs or hobbies involving the use of lead; and few children lived near industries that were thought by their parents likely to release lead.

TABLE 2. Responses to Risk Determination Questions

Question	No, %	Yes/Unsure, %
CDC questionnaire items		
Home built before 1960 with peeling or chipping paint?	50	50
Home built before 1960 with recent, planned, or ongoing renovations?	56	44
Friend/sibling with lead poisoning (lead level >/=15 [mu] g/dL)?	91	9
Adult in the home with a job or hobby involving lead?	84	16
Live near a battery recycling plant, lead smelter, or other industry likely to release lead	90	10
Additional items		
Family member who operates farm equipment?	86	14

Either or both parents **migrant** farm workers?	91	9
Child regularly spends time at day care or a baby-sitter's home?	65	35
Previous home with peeling or chipping paint?	65	35
Child ever lived outside of the United States?	96	4
Site of current residence		Proportions, %
Town		51
Farm		9
Outside of a town, but not on a farm		40
Rent or own home?		
Rent		50
Own		50
Number of times family has moved since child was 6 months old		
Never		49
Once		24
Twice		11
Three times		8
More than 3 times		7
Response missing		1

The additional questions that were listed on the risk assessment questionnaire dealt with both population-specific and general risk factors. The population-specific risk factors included determinations of whether family members operated farm equipment, whether either or both parents are **migrant** farm workers, and whether the child lives in a town, on a farm, or outside of a town but not on a farm. These items were included because leaded gasoline is still used to power many types of farm equipment; the children of **migrant** farm workers may be at particular risk for exposure to lead because of poor housing conditions and frequent changes of residence; and the relative lead exposures of children living on farms and in other rural settings is unknown.

The additional general risk factors included determinations of whether the child regularly attends day care or stays at a baby-sitter's home, whether the child ever previously lived in a home built before 1960 that had peeling or chipping paint, how many times the family had moved since the time the child was 6 months old, whether the child ever lived outside of the United States, and whether the family rents or owns their current home. Of note, as many as 35% of the children previously may have lived in homes built before 1960 that had peeling or chipping paint; as many as 26% had moved two or more times since being 6 months old; and as many as 4% had lived outside of the United States. Half of the children lived in rental housing.

As noted in Table 3, responses to four questions (two from the CDC questionnaire and two from the additional items that were asked) were found to be highly predictive of whether children had elevated blood lead levels (both 10 [mu] g/dL [0.48 [mu] mol/L] or higher and 15 [mu] g/dL [0.72 [mu] mol/L] or higher). Those questions related to:

. Whether the child has a brother, sister, housemate, or playmate with lead poisoning (defined

as a blood lead level of 15 [mu] g/dL or higher);
. Whether the child lives near a lead smelter, battery recycling plant, or other type of industry that is likely to release lead;
. Whether the family rents their home; and
. Whether either or both of the child's parents are **migrant** farm workers.

TABLE 3. Proportions of Children Having Elevated Blood Lead Levels Among Those With Affirmative/Equivocal Responses to Individual Risk Assessment Items

Item	>/=10 [mu] g/dL, %	>/=15 [mu] g/dL, %
CDC questionnaire items		
Home built before 1960 with peeling or chipping paint?	11.0 *	3.1
Home built before 1960 with recent, planned, or ongoing renovations?	8.1	1.9
Friend/sibling with lead poisoning (lead level >/=15 [mu] g/dL)?	19.4 ++	7.5 +
Adult in the home with a job or hobby involving lead?	8.0	2.7
Live near a battery recycling plant, lead smelter, or other industry likely to release lead?	17.8 +	6.8 +
Additional items		
Family member who operates farm equipment?	7.4	--
Either or both parents **migrant** farm workers?	22.6 ++	9.7 ++
Child regularly spends time at day care or a baby-sitter's home?	4.5 * §	1.2
Previous home with peeling or chipping paint?	13.5 ++	3.7
Child ever lived outside of the United States?	27.3 +	4.5
Site of residence:		
Town	10.9 +	3.6 +
Outside a town [parallel]	5.3 + §	0.3 + §
Rent home?	12.6 ++	4.0 ++
Moved 2 or more times since the child was 6 months old? [parallel]	12.6 *	3.1
Overall proportion of children with elevated blood lead levels, %	8.3	2.1

* P </= .05.

+ P </= .01.

++ P </= .001.

§ Apparent protective effect.

[parallel] Response categories consolidated for analysis.

Table 4 illustrates the RR of having a blood lead level higher than 10 [mu] g/dL (0.48 [mu] mol/L) or 15 [mu] g/dL (0.72 [mu] mol/L) for children whose parents answered any of the above four items affirmatively when compared with children for whom there were negative responses to the items. The significance of the association with elevated blood lead levels is also listed for each item. The item that was most significantly associated with elevated blood lead levels was the question concerning whether the family rented or owned their home. The children of renters had a nearly fourfold greater RR of having blood lead levels of 10 [mu] g/dL or higher than did the children of people who owned their homes (95% confidence interval, 2.0, 7.4). Of the 15 children who were noted to have venous lead levels of 15 [mu] g/dL or higher, all 15 lived in rented housing. The children of **migrant** farm workers were also especially likely to have elevated blood lead levels and, in particular, blood lead levels of more than 15 [mu] g/dL.

TABLE 4. RRs of Elevated Blood Lead Levels for Children Whose Parents Responded Affirmatively to the Questionnaire Items With the Greatest Predictive Utility Compared With Children for Whom There Was a Negative Response to the Items

	Lead Levels >/=10 [mu] g/dL		Lead Levels >/=15 [mu] g/dL	
	RR	P	RR	P
Rent home	3.8	<.001	-- *	<.001
Migrant farm workers	3.2	<.001	6.9	<.001
Friend/sibling with lead poisoning	2.7	.001	4.7	.006
Live near an industry that may release lead	2.4	.004	4.3	.01

* RR cannot be calculated. All children with lead levels of 15 [mu] g/dL or higher live in rented homes.

The effectiveness of the CDC questionnaire in either identifying children having blood lead levels of 10 [mu] g/dL (0.48 [mu] mol/L) or higher or 15 [mu] g/dL (0.72 [mu] mol/L) or higher is illustrated in Table 5. No statistically significant differences were found between the proportions of children having elevated blood lead levels among those categorized by the CDC questionnaire as either high or low risk. The sensitivities were about 0.75, whereas the negative predictive values ranged from 0.93 to 0.98.

Note: This table may be divided, and additional information on a particular entry may appear on more than one screen

TABLE 5. Effectiveness of the CDC Questionnaire and the Alternative Questionnaire in Correctly Identifying Children With Elevated Lead Levels

	CDC Questionnaire	
	Lead Levels >/=10 [mu] g/dL	Lead Levels >/=15 [mu] g/dL
High/unknown risk	9.0%	2.2%
Low risk	6.9%	1.9%
P	.44	.96
Sensitivity	0.75	0.74
Negative predictive value	0.93	0.98

TABLE 5. Effectiveness of the CDC Questionnaire and the Alternative Questionnaire in Correctly Identifying Children With Elevated Lead Levels

	Alternative Questionnaire	
	Lead Levels >/=10 [mu] g/dL	Lead Levels >/=15 [mu] g/dL
High/unknown risk	12.5%	3.6%
Low risk	2.4%	--
P	<.001	.003
Sensitivity	0.88	1.00
Negative predictive value	0.98	1.00

The four questions that individually were the most likely to identify children with elevated blood lead levels correctly (see Table 4) were combined into a questionnaire in the hope of forming an instrument that would be more effective than the CDC questionnaire in identifying these children. The effectiveness of this alternative questionnaire in correctly identifying children with elevated blood lead levels is noted in Table 5. Of the children considered to be at high risk according to the alternative questionnaire, 12.5% had blood lead levels of 10 [mu] g/dL (0.48 [mu] mol/L) or higher, compared with 2.4% of the children considered to be at low risk according to the questionnaire. This difference in proportions, corresponding to a 5.2-fold greater RR for children who are considered high risk by this questionnaire, is highly significant ($P < .0001$; 95% confidence interval, 2.4, 11.1). The sensitivity was 0.88, indicating that 88% of the children with blood lead levels of 10 [mu] g/dL or higher were considered high risk according to responses to the items on the questionnaire; the negative predictive value was 0.98, indicating that 98% of those classified as low risk by the questionnaire actually had blood lead levels of less than 10 [mu] g/dL. The alternative questionnaire was also effective in correctly identifying children with blood lead levels of 15 [mu] g/dL (0.72 [mu] mol/L) or higher. Of children considered at high risk according to the alternative questionnaire, 3.6% had blood lead levels of 15 [mu] g/dL or higher, whereas none of the children classified as low risk had blood lead levels of 15 [mu] g/dL or higher. Because the alternative questionnaire correctly categorized all of the children with blood lead levels of 15 [mu] g/dL or higher, both the sensitivity and the negative predictive value were 100% for detection of children with blood lead levels of 15 [mu] g/dL or higher.

DISCUSSION

The 1991 CDC statement on lead poisoning [n1] stressed risk assessment and encouraged the use of a five-item questionnaire at each regular office visit for children ages 6 months to 6 years to determine whether they are at high or low risk of having elevated blood lead levels. The CDC also suggested that risk assessment questions be tailored to the likely sources of exposure in particular communities and that prevalence studies be done to determine the extent of childhood lead poisoning problems in individual communities. In 1993, the American Academy of Pediatrics released a policy statement on screening and primary prevention of lead poisoning, which supported these recommendations. [n11] Although the screening recommendations of the CDC and the American Academy of Pediatrics remain controversial, the need for an improved risk assessment questionnaire, which is effective in correctly identifying children who are at risk for blood lead level elevations, is recognized even by those who suggest that the recommendations for universal screening be changed. [n10]

Previous studies have demonstrated varying prevalences of elevated blood lead levels among rural children. Weismann et al [n9] evaluated blood lead levels among 570 children screened in all but the four most populous counties of Iowa during a 6-month period of 1992. Surprisingly high proportions (23.9% and 14.1%, respectively) had blood lead levels of 10 [mu] g/dL (0.48 [mu] mol/L) or higher and 15 [mu] g/dL (0.72 [mu] mol/L) or higher. Because the 570 children screened represented only a small proportion of the children who should have been screened according to the CDC criteria, it is doubtful that the sample was truly random. Norman et al [n8] examined the prevalence of and risk factors for elevated blood lead levels among a nonrandom sample of low-income children residing in urban and rural areas in North Carolina. Approximately 20% were found to have blood lead levels (either obtained by venipuncture or by capillary sample collection methods) of 10 [mu] g/dL or higher, whereas approximately 3% were found to have blood lead levels of 15 [mu] g/dL or greater. Rural children in that study were significantly more likely than urban children to have elevated blood lead levels. In another study, Rifai et al [n7] found the prevalence of blood lead levels of 10 [mu] g/dL or higher among 120 rural children to be 5.8%, a percentage substantially less than the 18.6% of inner-city children in the same study whose blood lead levels exceeded this threshold but a somewhat greater percentage than the 2.4% of suburban children in the study who were noted to have elevated blood lead levels.

In the present study, 8.4% of rural children had blood lead levels of 10 [mu] g/dL (0.48 [mu] mol/L) or higher, and 2.1% had blood lead levels of 15 [mu] g/dL (0.72 [mu] mol/L) or higher. These proportions closely approximate the findings of phase I of the Third National Health and Nutrition Examination Survey, which reported that 8.9% of children nationally have blood lead levels of 10 [mu] g/dL or higher, and 2.7% have blood lead levels of 15 [mu] g/dL or higher. [n12] The proportions of children with elevated blood lead levels noted in the present study are significantly lower than those detected in the studies done by Weismann et al [n9] and Norman et al [n8] and are slightly higher than the proportions found to be elevated by Rifai et al. [n7] The differences in the prevalences of elevated blood lead levels between the present study and the other studies are likely to represent differences in housing characteristics, levels of poverty, and screening practices. Nevertheless, it is clear from all of the aforementioned studies that children living in rural areas are exposed to lead and may be at risk for elevated blood lead levels.

A substantially lesser proportion of children in the present study had elevated blood lead levels than was the case among children attending a hospital-based practice serving a largely inner-city population in a neighboring county of New York state 1 year earlier. [n2] This suggests that rural children in this geographic area may be less likely to have elevated blood lead levels than do impoverished inner-city children. However, the prevalence among rural children, although not as high as the extremely high prevalence for inner-city children, was not inconsequential. Therefore, it is imperative that there be a screening instrument that accurately indicates which children are at particular risk for exposure.

The CDC's lead risk assessment questionnaire was found to have little usefulness in the rural setting studied. No significant difference was detected between the proportions of children with

elevated blood lead levels who had been categorized as high or low risk. Although the sensitivity of the questionnaire was 0.76, indicating that 76% of the children with blood lead levels of 10 [mu] g/dL (0.48 [mu] mol/L) or higher, had been categorized as high risk, the overall proportion of children categorized as high risk in the study setting was also high, 69%, resulting in a high false-positive rate and decreasing the usefulness of the instrument for accurately detecting children with elevated blood lead levels.

Many respondents had difficulty with the questions relating to whether the child lives in a home built before 1960 that has peeling or chipping paint or recent, ongoing, or planned renovations. The nested nature of these questions (each of which asks a question within a question) and the requirement that the respondents know whether their homes had been built before 1960 account for the high proportions of those who had difficulty answering these questions. It may be more useful to ask about peeling or chipping paint or renovations without inquiring into the age of the home.

To evaluate the effectiveness of any screening test for identifying a condition or illness in a population, one must compare the proportions of persons categorized as being at high and low risk who have the condition. One also must evaluate the test's sensitivity, the measurement of how well the test identifies people with the condition, and the negative predictive value, the measure of the proportion of those having normal results on the screening test who do not actually have the condition. The lack of effectiveness of the CDC questionnaire in accurately identifying children who truly are at risk for elevated blood lead levels indicates the need to develop a screening questionnaire that is more specific to children living in rural settings. It was for this reason that the present study evaluated various additional potential questionnaire items. The alternative questionnaire included the items that were found to have the greatest predictive utility for correctly identifying children with elevated blood lead levels (both 10 [mu] g/dL [0.48 [mu] mol/L] or higher and 15 [mu] g/dL [0.72 [mu] mol/L] or higher) in the study setting. It had much greater effectiveness than did the CDC questionnaire, because a significantly greater proportion of children considered high risk by the alternative questionnaire had elevated blood lead levels than did low-risk children, because the sensitivity and negative predictive value of the alternative questionnaire were much better than those of the CDC questionnaire, and because the false-positive rate of the alternative questionnaire was lower than that of the CDC questionnaire.

The specific items that were included in the alternative questionnaire were the items that dealt with whether the family rents their home, whether either or both of the child's parents are **migrant** farm workers, whether the child has a friend or sibling with lead poisoning, and whether the family lives near an industry that they think may release lead. Renting one's home and belonging to a family of **migrant** farm workers were particularly highly associated with the child having elevated blood lead levels.

Intuitively, one could surmise that children who live in rental housing may be at particular risk, because it is likely that the condition of rental housing often is substandard when compared with the condition of owner-occupied housing. The findings of Sargent et al [n13] that geometric mean blood lead levels among the 9757 children living in Worcester County, MA, who were tested for lead in a 12-month period were significantly lower among those living in owner-occupied housing than among those living in rented housing confirm the association between rented housing and elevated blood lead levels noted in the present study. To evaluate this association further, we are currently assessing the degree to which living in rented housing is a predictor of elevated blood lead levels in an inner-city population.

It is not surprising that the children of **migrant** farm workers were particularly likely to have elevated blood lead levels. **Migrant** families move frequently and usually live in substandard housing. [n14-n16] The frequency of their moves from location to location may increase their children's exposure to lead, because the children are likely to live in a number of housing environments where lead may be a hazard. Additionally, the nutritional status of the children of **migrant** farm workers may be a factor, because it is likely that, as a result of poverty, the diets of these children may be relatively deficient in iron- and calcium-containing foods, as well as

other important nutrients, including zinc and protein. Because greater amounts of lead are absorbed among individuals who are iron, calcium, or zinc deficient than among individuals who have replete stores of these minerals, [n17] these children may be at particular risk when exposed to lead.

Several limitations may affect the generalizability of the results of this study. It was performed during a single season of the year and was restricted to children attending pediatric practices in a single rural county in the northeastern United States. Population characteristics, housing conditions, and rates of poverty in rural areas vary from region to region of the country. Lead exposure may vary similarly. Nevertheless, the finding that an alternative risk assessment questionnaire seems to be significantly more effective than the CDC's risk assessment questionnaire in correctly identifying rural children with elevated blood lead levels is important enough to warrant further investigation of its utility in other rural practice settings.

The nationwide decrease in mean blood lead levels noted in the Third National Health and Nutrition Examination Survey findings [n12] may increase the feasibility of approaches emphasizing targeted rather than universal blood lead screening among children. If so, the use of risk assessment instruments that have proven effectiveness will be vital. The results of the present study indicate that the same questionnaire which has been shown to be effective for urban [n2,n6] and suburban [n3-n5] children, seems to be less effective among rural children. Other risk assessment instruments may be more appropriate in rural settings.

Strategies for identifying children with increased lead levels should reflect local conditions. Risk assessment questionnaires, therefore, should include items related to specific risk associations of the population being tested. Accordingly, the effectiveness of any risk assessment questionnaire that is used should be evaluated to determine how accurately it identifies children with elevated blood lead levels.

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GRAPHIC: Figure, Distribution of elevated lead levels by age group.