Countryside Lead Prevalence Study

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Summary

Countryside Public Health Service (CPHS), and the Minnesota Department of Health (MDH) conducted a study of lead poisoning in Chippewa, Swift, and Yellow Medicine Counties. The project goal was to test every child up through 3 years old in those three counties for blood lead. Blood lead tests and lead risk questionnaires were obtained for a sample of 1,090 children less than 48 months of age (72% of the eligible population) between September 1, 2001 and August 31, 2002. Overall, 2.4% of children in the study had blood lead levels of 10 µg/dL (0.48 µmol/L) or greater (capillary and venous tests combined), 0.9% had venous blood lead levels of 10 µg/dL or greater, and 0.5% of study participants had blood lead levels of 20 µg/dL (0.96 µmol/L) or greater. When taken together, three risk factor questions predicted 90% of blood lead levels of 10 µg/dL or greater and all blood lead levels of 20 µg/dL or greater. This study estimated the prevalence of lead poisoning using a sample of the entire population rather than a clinic-based convenience sample. Targeted screening is an effective way to identify lead poisoned children in rural areas of Minnesota.

Background

Children under six years of age who spend time in homes built before 1978 with chipping or peeling paint are at greatest risk for lead poisoning. Younger children are susceptible because their bodies are still growing, their nervous system is still developing, and they are the most likely to put things in their mouths. Lead poisoning is often considered an inner city problem; therefore little screening is done in many rural areas. For example, the percentage of children less than six years old tested for lead in 2000 in most rural counties of Minnesota was 0.5-10% (Minnesota Department of Health, unpublished data) even though data from the 2000 Census show that rural areas of Minnesota frequently contain many of the same lead risks as high-risk urban areas, including a high percentage of children in poverty and a high percentage of housing built before 1950.

NHANES surveys provide national estimates of prevalence, but do not provide information at the state or local level. Most local studies have employed clinic-based convenience samples, and are not population based, meaning they may miss the most at-risk children. This limits their ability to make public health decisions. Population-based studies are needed to assess the relationship between lead risk factors and blood lead levels in rural children. To investigate the prevalence of EBLLs and lead risk factors in a rural area, we designed a study to examine blood lead trends in all children under age four in a primarily agricultural three-county area of Western Minnesota. Goals of the study were to estimate prevalence of elevated blood lead levels in a defined geographic area and test the efficacy of a screening questionnaire for predicting elevated blood lead levels in rural Minnesota.

Methods

The population chosen for study consisted of all children who were less than age four on October 31, 2001 in the counties of Chippewa, Swift and Yellow Medicine in West-Central Minnesota. These three counties are served by a common local public health agency, Countryside Public Health Services (CPHS). An eligible population of 1,514 children was identified by CPHS staff through a combination of local public health records, attendance at WIC clinics, and lead test results received by the Minnesota Blood Lead Surveillance System.

Active recruitment was performed from September 1, 2001 through August 31, 2002. Recruitment of study participants involved three main components: publicity to increase awareness of the study, mailing of information packets to eligible families, and recruitment at WIC clinics. Dinosaur graphics, obtained from the Los Angeles County Childhood Lead Poisoning Prevention Program and used with permission, were included on all study materials, including mailed materials, t-shirts, posters, and brochures. Approval from the MDH Institutional Review Board was obtained prior to beginning recruitment for the study.

Blood lead testing was performed at multiple locations. These sites included local medical clinics, Supplemental Nutrition Program for Women, Infants, and Children (WIC) clinics, CPHS offices and daycare facilities. Children were tested at medical clinics using either venous or capillary specimens when they were seen for well-child or sick visits. Results for tests performed at WIC clinics, day care sites, and CPHS offices were provided to each participant's medical clinic. The study questionnaire was a one-page survey to be completed by the parent or guardian containing questions about the respondent's home and other buildings the child may frequently visit (Table 1). These questions were answered with YES, NO, or DON'T KNOW (DK). A one-page informed consent form was on the reverse side of the survey. Participant confidentiality was strictly protected according to state and federal regulations.

Elevated cases were handled according to the Childhood Blood Lead Case Management Guidelines for Minnesota (Minnesota Department of Health 2001b). CPHS staff monitored identified cases, and close contact between CPHS and local clinics assisted the rapid implementation of case management. Lead hazard reduction assistance to families with children who have EBLLs was a major concern for both physicians and participants. Many families in the area do not have the resources to fix lead problems in their homes. The Sustainable Resources Center, a Minneapolis-based non-profit organization employing Community Lead Education and Reduction Corps (CLEARCorps) members, agreed to assist with lead hazard reduction activities in homes of children with elevated blood lead levels.

Results

Participation and EBLL rates are found in Table 2. Blood lead levels of 10 µg/dL or greater were identified in 26 children. Of these children, 21 were retested within the recommended three-month timeframe, and two were never retested. Ten of these EBLLs were confirmed to be 10 µg/dL or greater through a venous initial test or two elevated capillary tests. Blood lead levels of 20 µg/dL or greater were identified in five children, and all five were retested within the recommended one month timeframe, with three of these confirmed to be above 20 µg/dL through venous tests. The resulting prevalence rates were 2.4% for 10 µg/dL and above and 0.5% for 20 µg/dL and above, with confirmed rates of 0.9% for 10 µg/dL and above and 0.2% for 20 µg/dL and above.

The percentages of participants answering each survey question are presented in Table 3. Text of the questions can be found in Table 1. Prevalence ratios, sensitivities and negative predictive values for individual questions are presented in Table 4. The sensitivity of questions # 2, 3, and 5 combined was 90% for blood lead levels = 10 µg/dL and 100% for = 20 µg/dL. The negative predictive value for this combination was 99.7% for blood lead levels = 10 µg/dL and 100% for = 20 µg/dL. Using Fisher's exact test, the only question to significantly correlate with EBLL (= 10 µg/dL) was # 4 ($p<0.01$). However, this question was likely biased during the study because many parents completed the questionnaire after a blood test was taken for the study and results were reported to the family. Therefore for many children with EBLLs this question was answered YES, while it would have been NO if the survey were administered prior to the blood lead test.

A limited amount of data was available for eligible children who did not receive a lead test during the recruitment period, including completed risk factor surveys for 113 of the children who were not tested (Table 5). Non-participants were generally older, fewer of them lived in a pre-1950 home, and fewer of them were enrolled in Medicaid-funded programs.

Data from DHS was used to determine dates of enrollment in Medicaid-funded programs for both participants and non-participants. Of participants with completed surveys, 64% reported assistance through WIC or Medicaid. Using DHS records, 451 out of 1,090 (41%) tested children were enrolled in Medicaid when tested and 535 (43%) tested children were enrolled in Medicaid at some point during the study period. Of the total eligible population, 652 (43%) were enrolled in Medicaid at some point during the study period. Of the participants reporting assistance on the questionnaire, 44% were not enrolled in Medicaid at the time of the test, and 31% were not enrolled in Medicaid at any time during the study period. Of the participants reporting not being on assistance on the questionnaire, 5% were actually enrolled in Medicaid at the time of the test, and 14% were enrolled in Medicaid at some time during the study period. All of the children with confirmed blood lead levels of 20 µg/dL or greater were enrolled in Medicaid at the time of their blood lead test.

Addresses were located at county tax assessors' offices for 53% of the study participants and the age of their home was determined. Time spent in a pre-1950 home was reported by 66% of study participants on the questionnaire, while 60% of study participants actually resided in a pre-1950 home (of those found at assessors' offices). Of the participants indicating time spent in a pre-1950 home on the survey, 26% were found to be living in a post-1950 home. Of the participants not indicating time spent in a pre-1950 home, 38% of their addresses were found to be pre-1950 housing. All of the confirmed cases of 10 µg/dL or greater whose addresses were identified in assessor's records were found to live in homes built before 1950.

Discussion

The percentage of children with elevated blood lead levels in the study area was lower than rates found at the state level using blood lead surveillance system data. When capillary and venous tests were combined, approximately 3.3% of children tested and reported to the MDH lead surveillance system during 2002 had levels above 10 µg/dL compared to 2.4% in the study area and 0.4% of children had test results above 20 µg/dL in the statewide surveillance system compared with 0.5% in the study area (Minnesota Department of Health 2002). Blood lead test results reported to the MDH lead surveillance system do not constitute a representative sample of the state's children. Therefore it is more appropriate to compare the results of this study with other randomly sampled populations. Our findings for confirmed elevated lead levels (0.9%) were lower than the most recent NHANES survey (Centers for Disease Control and Prevention, 2003), which estimated that 2.2% of children nationwide had EBLLs using venous samples.

Because universal screening is not appropriate in many areas of the country, including rural Minnesota, the utility of screening questionnaires to predict EBLLs in rural areas has been investigated in several studies (Binns, LeBailly, Fingar, & Saunders, 1999; Hopkins, Quimbo, & Watkins, 1995; Kazal 1997; Muniz, Dundas, & Mahoney, 2003; Robin, Beller, & Middaugh, 1997; Schaffer, Kincaid, Endres, & Weitzman, 1996). Results from these studies suggest that the efficacy of screening questionnaires depends on the type and prevalence of risk factors in each area. Therefore, this study sought to test the validity of a screening survey in rural Minnesota, since most lead testing data in the state consist of urban populations. The survey questions with sensitivities greater than 50% for predicting confirmed blood lead levels above 10 μg/dL were: # 2; spending time in pre-1950 housing (86%), # 3; spending time in a pre-1978 home with remodeling or damage (71%), # 4; has the child or sibling had an elevated blood lead level (57%), # 5; receiving MA or WIC assistance (71%), and # 6; does the house contain lead plumbing or solder (86%). Because many participants did not know the status of their plumbing, question # 6 had a high percentage of DK answers. When DK answers were combined with YES answers for the purpose of screening and statistical testing, this may have lead to an artificially high sensitivity value for question # 6. Question # 4 may also have been biased during the study. Some questionnaires were completed prior to blood lead testing and some were completed after testing. As a result of this, some of the children who received a blood lead test that was elevated would have a YES answer for this question if the survey was completed at a later time, while they would have had a NO or DK response if the questionnaire had been completed at the same time as the blood draw for lead analysis. When combined, the remaining questions (# 2, 3 and 5) had a sensitivity of 90%. These three questions are included on MDH's screening guidelines and this study confirms their importance for screening. The relatively low cost, low risk (especially for capillary tests), and ease of interpretation of results for blood lead testing help to justify the inconvenience of testing a high percentage of children in rural areas.

National data suggest that children receiving assistance through the Medicaid program are a population at increased risk for lead poisoning; however, many of these children are never tested for blood lead. NHANES III found that Medicaid enrollees accounted for 83% of U.S. children aged 1-5 years who had blood lead levels of 20 μg/dL or greater (U.S. General Accounting Office 1998). Despite requirements for blood lead screening in the Medicaid program, an estimated 81% of young children enrolled in Medicaid nationally had not been screened with a blood lead test (U.S. General Accounting Office 1998). Minnesota shows a similar trend, with 70% of the Medicaid-eligible population not receiving a blood lead screen in 1998 (Boler et al. 2002). A survey of data from the Minnesota Blood Lead Surveillance System indicated that for children less than six years of age who had received a blood lead test in 1995-1998, approximately twice as many of those on Medicaid had EBLLs compared with children not on Medicaid (Castellano, Boler, Falken, Zabel, Michael, & Virnig, 2002). Results from the current study show the same trend, with a prevalence ratio for EBLLs of 1.6 for children whose guardians reported Medicaid or WIC assistance on the questionnaire. In addition, all of the children with blood lead levels of 20 μg/dL or greater were reported to receive Medicaid or WIC assistance on the questionnaire.

Validation efforts are extremely important when using self-reported questionnaire data. The validity and usefulness of questions # 2 and 5 was examined by independently checking Medicaid enrollment status and age of housing. Of respondents who reported no assistance through Medicaid or WIC, 5% were actually enrolled in Medicaid at the time of testing. Responses for these participants may be considered misclassified. Of respondents who reported assistance on the questionnaire, 44% were not enrolled in Medicaid. These responses cannot be considered misclassified because other government assistance programs are included in the question in addition to Medicaid-funded programs. For example, participants who responded YES on this question may have been enrolled in the WIC program, and therefore were not identified through DHS records of Medicaid-funded programs. WIC enrollment information was not available.

To evaluate whether participants responded accurately when asked whether the child spends significant time in a home built prior to 1950, age of the home was obtained for 53% of the eligible participants using tax assessor records. Approximately 60% of the eligible participants' homes that were identified were built before 1950, which is similar to the percentage of pre-1950 housing reported on the survey. However, for many participants the survey response did not correlate with tax assessor data. Of the participants indicating time spent in a pre-1950 home on the survey and whose addresses were identified at assessor's offices, only 26% were found to be living in a post-1950 home. It is possible that some of these participants spent significant time in a daycare, grandparents', or friend's home that was older than 1950. Of the participants who reported that the child did not spend time in a pre-1950 home, 38% of their addresses were found to be pre-1950 housing. This finding suggests that there may be substantial misclassification of risk based on self-reported age of housing. Another possibility is that some of the children whose questionnaire responses do not agree with assessor's records may have moved during the study period between newer and older housing or vice versa. Medicaid enrollment or assessor data are likely to be more accurate than self-reported questionnaire responses, however these data will not be routinely available for lead poisoning screening efforts.

Differences in risk between participants and non-participants may cause bias when estimating prevalence of lead poisoning in this rural area. Because the limited data available for non-participants showed that they were older, fewer of them lived in pre-1950 homes, and fewer of them were enrolled in Medicaid, the risk of EBLLs may be lower in non-responders. If so, the prevalence of EBLLs in the total population may be lower than was observed in this study sample.

Many rural areas of the U.S. have very low rates of blood lead testing in children, even though these areas frequently have a high percentage of old homes and children in poverty, two of the major risk factors for lead poisoning. This study found that the rate of elevated blood lead levels in a rural area of Minnesota was lower than the national average reported through NHANES data. Risk of elevated blood lead levels for children on Medicaid was two-fold higher than the risk for non-Medicaid children. A survey to assess elevated blood lead risk indicated that most of the children in the area should receive a blood lead test based on both state and CDC guidelines. Because lead poisoning risk in rural areas is more difficult to identify geographically than in urban areas, a large majority of children will continue to require blood lead testing in rural areas with a high percentage of old homes and children in low-income families.

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Table 1. Survey Questions

1*	Has the child moved from a major metropolitan area or another country within the last twelve months?
2*	During the past 6 months has the child lived in or regularly visited a home, childcare, or other building built before 1950?
3*	During the past 6 months has the child lived in or regularly visited a home, childcare, or other building built before 1978 with recent or ongoing repair, remodeling or damage (such as water damage or chipped paint)?
4*	Has the child, or his/her sibling or playmate, had an elevated blood lead level?
5*	Does the child receive services from Minnesota Care (MnCare), the Supplemental Food Program for Women, Infants and Children (WIC), or Medical Assistance (MA), which includes the Prepaid Medical Assistance Program (PMAP)?
6	Does your house have copper water pipes that are connected with lead solder or lead plumbing?
7	Does your child live with someone who works in a job or has a hobby where lead is used (i.e. sandblasting construction, welding, pottery, lead recycling, auto-body repair on old cars or tractors, radiator shops, stained glass windows, fishing tackle (sinkers) or reloading shells which use lead?
8	Does your child live near a heavily traveled highway where soil or dirt may be contaminated with lead?
9	Does your child live near a lead smelter, battery recycling plant or other industry that could release lead?
10	Does your child play on old playground equipment that has old chipped or peeling paint?
11	Does your child eat food from a garden that is close to a heavily traveled highway?
12	Has your child had a lead test before?

*These questions are included on MDH's standard risk screening questionnaire.

Table 2. Study Participation Rates and Elevated Blood Lead Level Rates in Children Receiving a Blood Lead Test.

	Chippewa		Swift		Yellow Medicine		Study Total	
Eligible Population	527		494		493		1,514	
Completed Survey	370	70%	387	78%	332	67%	1,089	72%
Completed Lead Test*	369	70%	390	79%	331	67%	1,090	72%
Completed Both	327	62%	359	73%	290	59%	976	64%
Initial BLL = 10 µg/dl†	11	3.0%	9	2.3%	6	1.8%	26	2.4%
Confirmed BLL = 10 µg/dl†	6	1.6%	1	0.3%	3	0.9%	10	0.9%
Initial BLL = 20 µg/dl†	2	0.5%	2	0.5%	1	0.3%	5	0.5%
Confirmed BLL = 20 µg/dl†	1	0.3%	0	0.0%	1	0.3%	2	0.2%

*Respondents may have a completed lead test without a completed survey because they were tested during a normal clinic visit without knowledge of the study.

†Initial BLL includes capillary and venous specimens. Confirmed BLL includes initial tests that were venous, follow-up elevated venous tests, and one case in which two capillary tests were 10 µg/dl or greater within 16 days.

Table 3. Responses to Risk Survey Questions for Participants with a Blood Lead Test.

Question	YES, %	NO, %	DK, %	Total Responses
1	3	97	0	808
2	49	34	17	976
3	37	52	11	976
4	2	75	23	976
5	65	35	0	808
6	10	32	58	976
7	19	78	3	976
8	13	81	6	975
9	0	97	3	976
10	4	93	3	976
11	2	97	1	976
12	20	73	7	941

Table 4. Prevalence ratio, Sensitivity and Negative Predictive Value for YES or DON'T KNOW Responses to Survey Questions Compared with NO Responses.

	BLL = 10 µg/dl[*] (Confirmed and unconfirmed cases)			BLL = 10 µg/dl[*] (Confirmed cases only)			BLL = 20 µg/dl[†] (Confirmed and unconfirmed cases)		
Question	Prevalence Ratio (95% C.L.)	Sensitivity, %	Predictive Value Neg., %	Prevalence Ratio (95% C.L.)	Sensitivity, %	Predictive Value Neg., %	Prevalence Ratio (95% C.L.)	Sensitivity, %	Predictive Value Neg., %
1	0.7 (0.2-2.3)	0	98	0.0[§]	0	98	0.0[§]	0	99.6
2	1.6 (0.6-4.3)	75	99	3.2 (0.4-26)	86	99	N/A[¦]	100	100
3	1.3 (0.6-3.1)	55	98	2.7 (0.5-14)	71	98	N/A[¦]	100	100
4	2.9 (1.2-7.0)[‡]	50	99	3.9 (0.9-17)	57	99	5.9 (0.5-64)	67	99.9
5	1.6 (0.5-4.7)	76	99	1.0 (0.2-5.1)	71	99	N/A[¦]	100	100
6	1.4 (0.5-3.8)	75	98	2.8 (0.3-23)	86	98	0.9 (0.1-10)	67	32
7	1.2 (0.4-3.1)	25	98	2.6 (0.6-11)	43	98	1.7 (0.2-19)	33	99.7
8	0.7 (0.2-2.5)	15	98	0.7 (0.1-5.8)	14	98	2.1 (0.2-23)	33	99.8
9	0.0[§]	0	98	0.0[§]	0	98	0.0[§]	0	99.7
10	1.4 (0.3-6.0)	10	98	2.1 (0.3-17)	14	98	0.0[§]	0	99.7
11	1.6 (0.2-11.6)	5	98	0.0[§]	0	98	0.0[§]	0	99.7
12	1.3 (0.5-3.1)	35	98	1.8 (0.4-7.8)	43	98	1.2 (0.1-13)	33	99.7

[*]There were 26 BLLs of = 10 µg/dl including confirmed and unconfirmed cases, among those with completed surveys, with seven of these confirmed.
[†]There were three BLLs = 20 µg/dl, including confirmed and unconfirmed cases, among those with completed surveys. Because there was only one confirmed case above 20 among respondents with completed surveys, analysis of risk ratios, sensitivities and predictive values was not possible for confirmed cases of = 20 µg/dl.
[‡]Statistically significant (p<0.01). See text for description of potential response bias for this question.
[§]No children with elevated blood lead levels had YES or DON'T KNOW responses to these questions.
[¦] Prevalence ratio cannot be calculated. All children with blood lead levels = 20 µg/dl had YES or DK answers for questions 2,3, and 5.

Table 5. Comparison of Participants and Eligible Non-participants.

Characteristic	Tested Children	Non-Tested Children
N	1,090	424
Mean Years of Age on 9/1/2002*	2.8	3.5
Completed Survey*	90%	27%
Reported Pre-1950 home (Q2 YES/DK) *	66%	56%
Pre-1950 home in tax assessor's records	60%	57%
Reported Assistance (Q5 YES/DK)	72%	65%
Enrolled in Medicaid During Study*	49%	28%
% Addresses found*	55%	47%

*Difference between tested and non-tested children was statistically significant ($p<0.05$).