ABSTRACT

HOLLY M. BIVINS. A Pilot Study Evaluation of Interventions Used By a Childhood Lead Poisoning Prevention Program to Reduce Elevated Blood Lead Levels. (Under the Direction of Dr. FRANCES LYNN)

This study evaluated a set of interventions used by the North Carolina Childhood Lead Poisoning Prevention Program to eliminate the elevated blood lead levels (BLLs) of 36 children. Abatement, education, housekeeping techniques, and relocation to lead-free housing were analyzed in terms of their effectiveness in significantly reducing BLLs. The study also assessed the attitudes, beliefs, and behaviors of the population at risk for lead poisoning. Health records and a questionnaire given to the families provided the data for the study.

Education provided by public health nurses was successful in improving the mothers' knowledge about lead poisoning, however, the vast majority of mothers were unaware of lead poisoning prior to their children's exposure. Although only four families were able to abate, all these children had significantly lower BLLs six to twelve months later. The majority of those children who used housekeeping techniques or relocation as an intervention also significantly reduced their BLLs. Based on answers to the questionnaire, most mothers expressed real concern for their children's situation, trust for the medical profession's ability to provide care, and a willingness to cooperate with the nurses and the health department.

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INTRODUCTION

Despite continual attention from federal and state governments through regulations and policies, childhood lead poisoning remains a serious national health problem. Reports issued in 1988 by the Agency for Toxic Substances and Disease Registry (1) estimate that 17.2% (2 to 3 million) of U.S. children under 5 years had blood lead levels (BLLs) exceeding 15 ug/dl. This is the level at which the Centers for Disease Control (CDC) currently recommends that interventions begin (13). Interventions include medical treatment (chelation therapy), education, abatement to remove the lead exposure, relocation, or housekeeping techniques.

The sources of lead in the environment as well as the effects of lead poisoning in children are well known. Lead sources responsible for poisoning are primarily man-made. Lead-based paint, storage batteries, secondary smelters and other industrial emissions, lead solder used in piping, as well as soil contamination from leaded gas emissions and leaded paint chips are significant sources of exposure for young children (5,12,14,25). Studies conclude that lead exposure occurs through inhalation of fumes and dust particles, and hand-mouth activity with soils, dust, and paint debris (5,7,12).

The effects of lead poisoning at levels higher than 80 ug/dl have been known for some time and include severe brain damage, convulsions and even death (13,21). Symptomatic effects from levels lower than 80 ug/dl include kidney damage, bone deformaties, and severe blood disorders (8,13). Less severe symptoms, which occur at levels as low as 45 ug/dl, include lethargy, anorexia, vomiting, and constipation (13,22).

Recent research indicates that there are serious asymptomatic effects which occur at levels previously thought safe. Levels between 10-25 ug/dl are now thought to have permanent adverse effects on children. Of utmost concern is the neurobehavioral effects seen at low levels of lead including I.Q. deficits and learning disabilities (18,19,26). Longitudinal studies show that low lead level exposure during childhood may result in irreversible effects on I.Q. levels as well as academic and social interaction problems in later years (2,19).

In order to eradicate childhood lead poisoning, children at risk must first be properly and quickly identified. Well-known risk factors for children include living in older dwellings with peeling paint, living near environmental sources such as lead smelters or heavily travelled highways, and having a caretaker working in a lead-related occupation. Children who exhibit an appetite for non-food items (pica), particularly paint chips are also

at high risk (11,13). Although all young children can be susceptible, children in low socioeconomic families typically have more of the preceding risk factors. Lower socioeconomic children can also be more susceptible because of their poor nutritional habits: iron deficiency typical of poor families can result in an increased uptake of lead into the body (17). Thus, childhood lead poisoning disproportionately affects poor and minority families (13).

The purpose of this research was to examine a set of intervention strategies used by the North Carolina Childhood Lead Poisoning Program (NCCLPPP) and discuss their relative effectiveness in lowering BLLs of poisoned children. The NCCLPPP was created in 1982 through funds received from the Maternal and Child Health Block Grant Program. The program's goals are to 1) provide for the prevention and early management of childhood lead exposure; 2) identify the populations at risk for childhood lead poisoning; and 3) implement legislation to prevent and control childhood lead poisoning in NC (20). In achieving these objectives, the program is committed to adhering to CDC guidelines on the prevention of childhood lead poisoning. The program's duties include 1) targeted screening of children for lead poisoning; 2) laboratory analysis to identify lead poisoned children; 3) surveillance of identified children; 4) follow-up activities including education and environmental assessment; and 5) providing recommendations to landlords

and families regarding hazard elimination procedures (20).

In 1991, there were thirty-nine children confirmed by the NCCLPPP as having elevated BLLs. Because of this limited number of children involved in the NCCLPPP when the research was initiated, this study was undertaken as a qualitative pilot study. Any full-scale statistical or epidemiological analysis would not provide meaningful results due to these small numbers. The research examined the relationship of intervention strategies such as abatement, housekeeping techniques, and health education to the prevention of childhood lead poisoning. Other disease prevention studies indicate the important role of a person's attitudes, beliefs, and behavior to the success of an applied prevention program (3,16,29); therefore, the effect of these variables were also considered in this study. Knowledge of the many factors involved in successfully lowering BLLs is pertinent to reaching the national goal, as stated by the Public Health Service (23), of eliminating childhood lead poisoning.

The results of this pilot study should provide useful information for state and local disease prevention programs in designing more effective prevention protocols to address childhood lead poisoning. This study will also provide specific information to help evaluate North Carolina's current prevention program. Future research can utilize the recommendations of this pilot study to develop larger

epidemiological studies on lead poisoning intervention efficacy.

METHODS

General Study Design

In order to evaluate the interventions used by the NCCLPPP, a qualitative study was designed. A group of children being assisted by the program were divided into two groups based on their relative BLL reductions. One group had a significant overall BLL reduction whereas the other group did not. Selected variables were selected to explain the discrepancies in BLL reductions between the two groups. Descriptive information gathered from a questionnaire provided insight to the attitudes, beliefs, and behaviors of the population at risk. The questionnaire also helped to determine the family's overall satisfaction with the services of the NCCLPPP.

Study Group Description

The study population was identified from records maintained by the NCCLPPP. This population consisted of all children who entered the program after January, 1991 with a confirmed elevated BLL of 25 ug/dl or higher. A total of 39 children met these preliminary criteria. Follow-up procedures immediately began for children with BLLs in this elevated range. Public health nurses typically recorded medical histories of the children and provided education to the families. Lead investigators then performed an environmental assessment to determine the lead sources.

Surveillance of these children usually continued until they were no longer at risk. Therefore, longitudinal data provided information on changes in BLL during and after intervention. After data from each of the children's records were gathered and assessed, three children were eliminated from the study due to missing records. The records of most of the remaining thirty-six children contained information on BLL measurements, health history, interventions used, and any evidence of relocation.

In addition to using the data contained in health records, visits and interviews with the mothers of a sample of the population group were performed (see Appendix A). Due to time constraints on this pilot study, mothers of only fifteen of the remaining 36 children were interviewed. The criteria for selection of these fifteen included thoroughness of their records, and ability to contact them by telephone or via their county health department. Because of the low frequency of abatement among the study group (n=4), all of these cases were selected to be interviewed in order to gather more information on the use of abatement as an intervention. The families interviewed also included cases which involved interesting sources of exposure: a lead musket shot and occupational lead-dust. The questionnaire was directed to the mothers because they were the primary caregivers for the family. The interview typically lasted thirty minutes as many mothers offered to

explain their situation in-depth. The fifteen interviews took place at each family's residence and involved travelling to ten different counties.

A separate group of 24 children was chosen from the Program to provide some comparison to those interviewed from the study group. These children were involved in another lead poisoning study investigating the exposure sources for children with elevated BLLs between 15 ug/dl and 24 ug/dl. Because these children had lower initial BLLs than the study group, they did not receive equivalent levels of intervention (i.e. education, abatement, or relocation) from the Program. Only approximately half of these families, instead, received a standard informative pamphlet with little or no additional education from the public health nurses. Comparisons between the two groups included the mothers' knowledge of lead poisoning and their attitudes, beliefs, and behavior in response to this knowledge.

Identification of Variables

The dependent variable related to intervention effectiveness was each child's PbB measure. The confirmed elevated BLL before the period of intervention was compared to a BLL taken at least six months into the post-intervention period. The degree of BLL reduction was the difference between the two measurements. Health department personnel performed all PbB measurements using either venous

or capillary methods.

The study analyzed several independent variables in terms of their relationship to the dependent variable (see Table 1). The first set of independent variables assessed was the actual intervention used in each case. County health department personnel typically provided the education program to the families. This study evaluated the education program by measuring the mother's knowledge about lead poisoning. Other variables examined included abatement procedures performed and learned housekeeping techniques. Abatement is defined as the permanent removal of lead exposure to the child through remediation techniques. Housekeeping techniques, on the other hand, are used to temporarily remove the lead hazard by sweeping, vacuuming, wet cleaning, or dusting. These techniques are taught through the education process. The last variable evaluated in this particular set was relocation to lead-free housing. This study did not necessarily evaluate the effectiveness of chelation therapy as an intervention but did consider its overall use within the study group.

The family's attitudes, beliefs, and behavior were related to the family's knowledge of lead poisoning and the interventions provided. There have been many studies which directly relate these variables to the relative success of disease prevention programs (3,16,29). This study used the Health Belief Model (HBM) as a guide to define attitudes,

beliefs, and behavior variables related to childhood lead poisoning (3). The current HBM consists of six parts relating to a person's willingness to comply with a disease prevention intervention: motivation to avoid an illness/get well, perceived susceptibility to an illness, perceived severity of the illness, perceived barriers to compliance, perceived benefits to compliance, and a measure of self-efficacy (3). By assessing the attitudes and beliefs of these families, descriptive information about the population at risk could be attained.

Although this study attempted to evaluate the interventions used for the study group, other factors such as socioeconomic status and child-caretaker interactions were also included. Other childhood lead poisoning studies have recognized the role of these variables in determining at-risk populations (4,28).

Data Sources

This study used records from the NCCLPPP to obtain information on each case. After a child screens positive for an elevated BLL, a repeat test is performed for confirmation. The NCCLPPP then begins standard procedures which include education by a public health nurse, environmental investigation of the exposure sources, and repeat blood testing, usually every three months. The records contained information on each case. Information

extracted from the records for each of the thirty-six cases included health history, BLL measurements, home and county residence, abatements performed, evidence of relocation, and the primary nurse investigator. The nurses or lead coordinators involved in each county were also available for information on the cases. The environmental investigations determined the sources of lead exposure. The health records provided the results of these investigations as well as any medical treatment used to lower BLLs.

A questionnaire attempted to gain information on the family's response to their experiences with the NCCLPPP as well as their attitudes, beliefs, and behavior related to childhood lead poisoning. This original questionnaire consisted of the following five sections: 1) parent's knowledge about lead poisoning; 2) questions about the home inspection and any abatement; 3) child's medical treatment; 4) parent's thoughts on medical care in general; 5) and general information about the family. The questionnaire was closed-ended, but the mothers were encouraged to clarify or discuss further any of the questions as desired.

Each section of the questionnaire attempted to gather information on the child's specific situation and story. Most of the sections also contained questions using the Health Belief Model as a guide. These questions helped to collect information on the family's attitudes and beliefs about lead poisoning. Table 2 provides some sample

questions used in the interview.

Another question was added to the questionnaire to assure that all topics of interest for each mother were addressed. This question provided an opportunity for the mother to discuss anything about her experiences that was not previously covered. Two health professionals in the N.C. Department of Environment, Health, and Natural Resources tested content validity. The questionnaire was revised several times in response to comments on its understandability and simplicity.

Data Analysis

The information from the records and the questionnaire was coded and entered into Statistical Analysis Software (SAS) data file for basic statistical analysis. With the use of this basic data, comparisons could be made between different cases thus providing information about the basic outcomes of the interventions used within the NCCLPPP.

The interventions used in the individual cases were evaluated in terms of their ability to significantly lower BLLs. The cases were divided into categories of relative BLL reduction, and the frequencies of interventions used in each group were compared. Two sets of groups were formed based on two different definitions of a significant BLL reduction. The two definitions, a reduction in BLL of 10 ug and a reduction in BLL to below 25 ug/dl, therefore were

used to evaluate the interventions used. Table 3 provides simple definitions of these groups.

The first set consisted of a group of children whose BLL dropped by more than 10 ug (Group A) and a second group of children which did not achieve this level of reduction in BLL (Group B). Other studies evaluating the effects of abatement on BLL reduction have used this definition (7,27). Using a reduction of at least 10 ug/dl also reduces the chance of laboratory error in blood analysis (13).

The second definition of a significant BLL reduction was based on the action level used when these children entered the program in 1991. At that time, complete intervention began for children with confirmed elevated BLLs above or equal to 25 ug/dl. Once a child's level went below this action level, the child was considered improved. Many nurses would not continue the intervention program for these children at the same level of intensity. Therefore, those children whose most recent BLL was below 25 ug/dl (Group C) and the remaining children whose recent BLL did not achieve this reduced level (Group D) formed the second set of two groups.

Due to the small number of families interviewed, the same group divisions by BLL reduction could not be performed to evaluate the variables addressed in the questionnaire. Therefore, any data ascertained from the questionnaire was analyzed as a single group. This data provided descriptive

information about the families involved in the program.

RESULTS

Descriptive statistics produced from information in the case records provided a general overview of the study population. Table 7 provides a flow chart describing the children in the program by method of intervention, source of exposure, relative BLL reduction, and inclusion in the interviewed sample. The highest initial elevated BLL reading among the study population was 64 ug/dl, and the mean initial reading was 35.3 ug/dl. The mean BLL reduction was 15.4 ug/dl, and the mean latest BLL reading was 21.0 ug/dl. The records of thirty-three children contained enough information to group BLL readings based on their relative reductions. Twenty-one of these children (64%) had more than a 10 ug/dl reduction in BLL from their initial readings (Group A). Twenty-four of these children (74%) had their latest BLL reading under 25 ug/dl (Group C).

The records of thirty-one children contained information on the source of lead exposure. Twenty-seven of the children (87%) received their exposure from lead-based paint and/or dust and soil contaminated from lead-based paint. Three (10%) received exposure from contaminated particles brought home by parents exposed to lead in their occupation. The remaining case received exposure from a lead musket shot which she repeatedly put in her mouth. The records of thirty-three children contained information on the method of intervention used. As mentioned before, only

four children (12%) received formal abatement to permanently eliminate their exposure. Twenty-one (64%) moved to new housing to avoid further exposure whereas eight children (24%) remained in their unabated homes and used housekeeping techniques to reduce their exposures. The mean reductions in BLLs for those who abated, relocated, or used housekeeping techniques were 23.3 ug/dl, 14.6 ug/dl, and 12.3 ug/dl, respectively. Eleven of thirty-six children with complete records (31%) received medical treatment (such as chelation therapy) because their blood lead levels were exceptionally high.

Variables from the health records were used to compare the characteristics of the interviewed group (n=15) and the remainder of the study group. Table 4 provides an analysis of any differences between the interviewed sample and the remaining uninterviewed group based on variables extracted from the children's health records. Such a comparison can help determine if the information gathered from the interviewed sample can be generalized to the entire study group. 71.5% of fourteen children in the interviewed sample received their exposure from paint, or paint-contaminated soil and dust, whereas all those in the uninterviewed group had this exposure. The percentage of those receiving medical treatment (e.g., chelation therapy) was equal in both groups. Because all those families which abated were chosen to be in the interviewed sample, there was no

incidence of abatement in the uninterviewed group. There was a large discrepancy in relative BLL reductions between the two groups. For example, 80% of the interviewed sample had a BLL reduction of more than 10 ug/dl while only 33.3% of the uninterviewed group had this same significant reduction.

Blood Lead Level Changes and Impact of Education

All cases which abated (n=4) had BLL reductions larger than 10 ug/dl and a latest BLL reading under 25 ug/dl (Table 5). Twelve of the twenty-one children (57%) who relocated had a BLL reduction larger than 10 ug/dl. Fifteen of these same twenty-one children (71%) had a latest BLL reading under 25 ug/dl. For those children who remained near the exposure and used housekeeping techniques (n=8), five (63%) had a BLL reduction over 10 ug/dl. The same number of children also had their latest BLLs below 25 ug/dl. All children received education as part of their intervention.

Questions asked during the interview assessed the mother's knowledge about lead poisoning and thus provided an evaluation of the education used by the health care providers. These questions were formulated based on information in the pamphlets the mothers received as well as on other basic facts about lead poisoning. Fifteen of the mothers in the study group answered these questions. The

mothers of the twenty-four children which had BLLs between 15 ug/dl and 24 ug/dl also answered these knowledge questions. The data is presented in Table 6. Because those in the study group had more elevated initial BLLs, they received more in-depth education than those in the comparison group. For many of the questions, there was a large difference in those answering correctly between the study group and the comparison group. For instance, eight of ten mothers in the study group understood that mopping the lead-exposed areas in the house would be very helpful. However, only seven of the twenty-four mothers in the comparison group knew this fact.

Attitudes and Beliefs

The questions formulated using the Health Belief Model and given to the fifteen mothers in the study group provided information about the family's attitudes and beliefs about lead poisoning and health care in general. The comparison group (n=24) also received the same questions. Both these groups represent a sample of the overall population at risk. Therefore, both group's responses to these Health Belief Model questions were combined to provide total results. However, not all mothers from both groups answered each question. Thirty-one of thirty-eight mothers (82%) interviewed could easily find transportation to the doctor when necessary. However, ten of these mothers (26%) agreed

that it was difficult to find the time to go to doctors' appointments. Thirty-six of thirty-eight mothers (95%) believed that going to the doctor for check-ups would improve their children's health. The mothers were asked if they believed they had already helped their children get better. Thirty-two of thirty-eight mothers (84%) said they felt they had. Thirty-five of thirty-eight mothers (92%) agreed that a doctor or nurse can help their children get well. Thirty-two of thirty-eight (84%) said that when their children get ill, they would most likely take them to the doctor. Lastly, twenty-five of thirty-seven mothers (68%) believed that lead poisoning was more serious than the many other dangers to which their children are exposed.

Other questions exclusively asked of the fifteen mothers in the study group helped gather information on the mothers' level of satisfaction with the services of the NCCLPPP. All these mothers received informative pamphlets about lead poisoning, and thirteen (87%) of them found the pamphlets very helpful. The case health-care providers typically demonstrated how to keep the children away from the lead sources, and nine of the mothers who received this instruction (n=13) found it very helpful. The lead inspectors involved in the case also provided information on lead poisoning to twelve of the fifteen mothers. Ten of these mothers (83%) found this assistance very helpful. In eleven of the cases (92%), the inspectors also took the time

to show the family the locations of the lead sources. However, when asked if they were aware of the dangers of lead poisoning before their children were tested, thirteen of the fifteen mothers (86%) admitted they had no previous knowledge.

Nine of the mothers who moved or remained at the exposure source received questions regarding why they did not abate. Six of these mothers (68%) said they were not responsible for abatement because they were renting their homes. All of these mothers indicated that abatement was too costly.

The last questions in the interview considered socioeconomic status and child-caretaker interactions. Six of the fifteen mothers (40%) interviewed had at least four children living in the home. All of the families had medical insurance; eight of the fifteen (53%) had insurance through medicaid services. All mothers completed high school, and two out of the fifteen went on to complete college. Eight of the families (53%) had less than $15,000 per year in income, but six of the families (40%) received more than $20,000 in income.

DISCUSSION

Information from the records and the interview helped to describe the specific population at risk for lead poisoning in North Carolina. The mean initial BLL reading for these children was not exceptionally high; however, it was high enough to assume that some permanent damage could have taken place. Using two methods to determine significant BLL reductions, the group as a whole received successfully-implemented interventions. Most lead-based paint abatement studies tested homes in large urban cities (5,7,9,10,15,24), thus providing evidence that lead-based paint is the major source in these areas. However, less information is available concerning the major sources of lead in rural and small towns. Based on the records examined for this study, the primary source for exposure was also lead-based paint. The homes of these children were located in rural areas or small towns. Therefore, lead-based paint is a major cause of lead poisoning in rural as well as urban areas.

Socioeconomic status (SES) helped to describe the population at risk. Not all families were considered to be of low SES based on income and maternal education. Therefore, although low SES, in general, is associated with an increased risk, other sectors of the population may be at risk as well.

All those interviewed had medical insurance; a majority

were enrolled in Medicaid programs. This fact may indicate a bias in the children screened by the NCCLPPP. Most of the children screened by the NC program have Medicaid which currently mandates PbB screening. However, a large population at risk may not be in the Medicaid program and thus are much less likely to be tested. The following simple statistics indicate that screening is not being adequately performed. Census data from 1990 estimate 549,276 children under six years old living in NC (20). Brewer et al. (6) suggest that there may be up to 8,222 children and 87,356 children under six years in NC with BLLs over 25 ug/dl and 15 ug/dl, respectively. The NCCLPPP screened a total of only 23,790 children under six in 1991, 39 of whom were confirmed as having BLLs equal to or above 25 ug/dl. Many children in NC are without any health insurance or have private insurance which does not cover the cost of testing. These situations help to explain the obviously low screening rates.

There were positive child-caretaker interactions within these families as well as positive attitudes about the abilities of medical personnel. Most mothers said they would take their sick child to the doctor/nurse because they felt the doctor/nurse could help. Therefore, these mothers perceived large benefits from going to the doctor. These mothers also realized the dangers of lead poisoning and thus would be more likely to do their best to help their

children. This descriptive information about the mothers may help the NCCLPPP in designing prevention efforts. Once these mothers are properly educated about lead poisoning, they show real concern for their children, and this should be a positive factor in their children's recuperation. These feelings of concern should be reinforced as they indicate a mother's willingness to cooperate with the personnel in the program.

However, there are barriers which may lessen this positive effect. Most mothers discussed the everyday tasks and chores which often keep them busy through the day. These typical everyday tasks could inhibit the mothers from providing their best efforts to see that their children are protected from lead poisoning. A few found that the hospital was far away and transportation was sometimes difficult to find. Large family size could increase the difficulty of performing the duties required to reduce children's exposure. Two interviewed mothers each had families of nine.

A comparison between the interviewed sample and the remainder of the study group provided information on any different characteristics between the two. The methods section discusses how the interview sample was chosen. However, as Table 4 indicates, there was an unintentional difference in BLL reductions between the interview sample and the remaining study group. The more significant BLL

reductions in the interview sample may be a result of criteria used for selection into this group. The interviewed sample included all those children who received abatement (n=4) as an intervention. All these children experienced significant BLL reductions by both definitions. This fact may help to explain the disproportionate frequencies of significant BLL reductions in the interview sample. Another explanation may be the differences in lead sources among the two groups. The interviewed sample also included children who had a source other than lead based paint. These sources (occupational dust, lead musket shot) may have been easier to eliminate with less expense and time involved. Therefore, these children may have added to the disproportionate frequencies of significant BLL reductions in the interview group. This apparent difference in BLL reductions implies that the data from the questionnaire reflects the opinions of those mothers which benefited the most from the interventions received. That is, the interventions used for those in the questionnaire group were relatively successful.

Information from the records and the interviews helped to explain and evaluate the interventions used by the NCCLPPP. Abatement proved to be a successful intervention in all four cases in which it was used (see Table 5). The abatement techniques used for these four children included encapsulation, replacement, and scraping and disposal of

lead based chips. However, the fact that only four of the twenty-seven cases involving lead based paint used abatement indicates a serious problem. The primary reasons for the low incidence of abatement is its large expense as well as landlords who may be uncooperative in performing the necessary repairs. At least one of these reasons forced most families to move. The U.S. Department of Housing and Urban Development (HUD) has estimated average abatement costs for a single housing unit by either encapsulation or removal methods (30). The majority of units abated by either method would cost $2,500 or less. However, those units having multiple lead-based paint surfaces would cost an average of $8,870 for encapsulation and $11,870 for removal. Those homes with peeling lead-based paint would cost much more to abate.

Although personnel from the NCCLPPP have the right to prosecute those who refuse to abate, this seldom occurs. By taking legal action, the families could lose their homes, leaving them in an even worse situation. In one instance, a mother was almost forced out of her rented home after asking her landlord several times for the required abatement. It was only after much pressure from the state health department that the landlord complied. Although the abatement was completed, the mother still feels strong tension between herself and the landlord and is therefore still considering moving. The expense of abatement is not

just a problem inherent to the NC program, as all lead poisoning programs must deal with this problem. Further studies of the use of abatement in NC should include interviews with the landlords and/or abators to learn more about the forms of abatement used in each case as well as their opinions on the issue of abatement. Gaining more information could be helpful in pinpointing some problems as well as ultimately finding some solutions.

Relocation was the more utilized intervention. Based on the number of significant BLL reductions as a measure, relocation was not as successful as abatement (see Table 5). Nevertheless, the majority of those who relocated experienced a BLL reduction of at least 10 ug or had their latest BLL under 25 ug/dl. The fact that these mothers moved their families provides further evidence of their true concern for their children as well as their understanding of the dangers of lead poisoning. However, relocation involved many logistical problems for the families such as finding another affordable home which was lead-free. One resourceful mother's story provides an example. After being informed that her child had lead poisoning and her newly purchased first home contained the source, she received no help from the seller to pay for abatement. Having spent all the family's savings on the home, she became very concerned about finding low-rent housing large enough for her family of nine. She finally contacted her Congressman, told him of

her special situation, and was eventually able to find housing with his help. The same provisions for those in similar situations, however, can not be guaranteed. Using relocation as an intervention leads to many other potentially negative effects. Moving does not necessarily guarantee an exposure is no longer present, as the family can very easily move into another lead-contaminated house. Moreover, any child who moves into the originally contaminated home becomes an addition to the at-risk population. Further studies evaluating relocation as an intervention for childhood lead poisoning could analyze the frequencies of these situations.

In the study, housekeeping as an intervention performed moderately well in terms of lowering BLLs (see Table 5). Unlike abatement and relocation to lead-free housing, housekeeping is not a permanent solution. Whether or not housekeeping techniques work depends on multiple factors. The mothers must receive proper training in the ways to clean, have the time to do frequent and thorough cleanings, and be financially able to purchase the proper cleaning supplies. With so many variables involved in the success of housekeeping, problems are likely to arise. One family remained in their lead-contaminated home and, due to high costs, was not able to abate. The county lead investigators were unable to complete their first investigation to locate all the lead sources because their equipment malfunctioned.

Although the workers returned several times to finish the investigation, the mother remained unsure of all locations of the lead sources. Therefore, her attempts to decrease exposure by cleaning was considerably ineffective.

Based on an analysis of the mothers' knowledge about lead poisoning, the education used by the health care professionals was a successful intervention (Table 6). The data indicate that those mothers which received thorough education (i.e. the study group) had more knowledge about lead poisoning than those mothers which did not receive equivalent levels of education (i.e. the comparison group). According to these results, the health care providers are doing an adequate job of educating the families. The more thorough education often involves repeated visits to the homes as well as continual written and verbal reminders to the mothers regarding doctor appointments. All the mothers in the study group received pamphlets on lead poisoning, and some of the mothers in the comparison group similarly received pamphlets. Although these pamphlets contained the same information, it is obvious that the mothers in the study group were more knowledgeable about this information. The additional factor of thorough and repeated discussions by the nurses involved with the study cases is obviously beneficial. The nurses typically use the pamphlet material as a guide to more fully explain lead poisoning in such a way that the mothers can better understand. One nurse even

created her own additional information sheets to give to her patients. This material was formulated to be interesting and simple for the nurse's specific cases. The mothers' overall high level of satisfaction with the nurses and the NCCLPPP is another indicator of the success of the education program.

Whether or not this level of individual attention and education can continue with the expected rise in cases is questionnable. Due to the new lower level signaling an elevated blood lead (15 ug/dl), the more precise screening method now being used, and the more efficient laboratory equipment being used, the number of cases is expected to increase considerably. In fact, within the first two months of 1993, 241 cases were already identified as having BLLs above 15 ug/dl. This is compared to the 39 elevated BLL cases identified in all of 1991, using 25 ug/dl as the action level. The NCCLPPP will require more funding to maintain adequate resources for the increase in screenings, lead investigations, and laboratory procedures. But just as important, the program will have to train additional personnel to adequately provide education for this new caseload. More resources will be required in order to maintain the current level of individualized instruction for all cases. The current number of nurses will not be able to handle the expected increased caseload and still provide the same amount of time and care to each case.

Although the mothers answered most of the knowledge questions correctly, there were several questions with a high percentage of wrong answers chosen. For example, most mothers believed that sweeping paint chips to the outside was very helpful. They felt that by removing the chips from the interior, the exposure was no longer present. However, sweeping the chips outside only transfers the area of exposure and may cause recontamination. This indicates that some aspects of the education program may not be thorough enough. Health care providers must be sure to stay abreast of current lead poisoning literature and provide this information to their patients.

One serious problem discovered through the interviews is that a full 86% of the mothers were unaware of lead poisoning prior to the screening of their children. This strongly suggests that the NCCLPPP is not adequately targeting at-risk populations for education before the poisoning occurs. The easiest way to control the increase in lead poisoning is to provide education to parents of children at risk before they experience dangerous levels of exposure. The CDC has indicated this primary prevention as a national priority in eliminating childhood lead poisoning (13). The NCCLPPP must first identify and target the high-risk communities based on known risk factors. There is an ongoing research effort in NC attempting to locate communities which may be at risk based on SES factors, age

of housing, location near an enviromental source, etc. This research uses geographic computer software to quickly and accurately locate the at-risk population.

Once this population is identified, there are several ways the NCCLPPP could provide this pre-exposure education. First, health department personnel working with future mothers or mothers with newborns should immediately proceed with education and not wait until a blood lead test is performed. Second, both private and public pediatricians and general practicioners should be educated on the dangers and high incidence of lead poisoning. Once they are properly educated, they will become much more of a factor in identifying and caring for the at-risk population. Third, the NCCLPPP should implement community-wide intervention activities. By addressing the community, mothers which otherwise would not have been reached can be identified. Introducing the general knowledge about lead poisoning into the community can ultimately increase the number of at-risk children identified prior to exposure. Theoretically, with more mothers made aware of the dangers of lead poisoning before their children are exposed, the number of children eventually poisoned will decrease.

Examples of current or upcoming national education programs include the following: 1) the Council on Environmental Quality's lead poisoning prevention education campaign including T.V. and radio public service

announcements; 2) a new federal interagency hotline providing information materials and brochures through the U.S. Environmental Protection Agency; 3) and the National Lead Information Center providing information on lead poisoning, home repairs, and environmental testing of homes. Information on these national education programs must be made available through the state and local agencies to the population at risk. Currently, NC public health departments are being instructed on how to handle the expected increase in inquiries about lead poisoning. Information materials have been created addressing commonly asked questions about lead poisoning.

Performing this pilot study involved several problems. One major difficulty was contacting enough mothers to interview. Many mothers were unreachable because they had no telephone or had moved to an unknown location. Two mothers who originally agreed to the interview were not at home at the agreed-upon time. A large amount of time was spent contacting nurses, health departments, and the families, but ultimately, only the mothers of fifteen children could be interviewed. The uncertain validity of some of the questions in the interview was also a problem. For instance, many of the attitude and belief questions modelled from Health Belief Model studies were interpreted quite differently by different mothers. For example, when asked whether they would take their child to the doctor when

sick, several mothers said probably not because their children usually got only a simple cold. These mothers who said they would not take their children to the doctor may still trust doctors and medical services as well as have concern for their children. Therefore, the responses to these Health Belief Model questions may not be meaningful.

Future studies could use this pilot study to determine several important aspects to evaluate an intervention program. Using similar methods in a larger case-control study may provide significant results. The NCCLPPP has already begun revised procedures to provide case management to children with BLLs now considered elevated as well as to expand the screening program. Therefore, the numbers of lead poisoning cases identified has already greatly increased, providing a larger population for a more formal study. As previously mentioned, 241 cases were identified in the first two months of 1993, all of which should at least be receiving parental education and repeat testing.

Consideration in similar future studies should include not only interviews with the mothers but also interviews with the nurses and lead abaters. The nurses can provide invaluable information on their educational and teaching methods as well as their personal experiences with the families and the NCCLPPP. Having such integral positions within the program, the nurses can offer significant advice and opinions on the program's effectiveness. Interviews

with the abaters can provide information on the actual abatement techniques used; therefore, a more thorough evaluation of this specific intervention can be completed.

Table 1: List of Independent Variables Used to Explain BLL Reductions of Children Enrolled in the North Carolina Childhood Lead Poisoning Prevention Program

INTERVENTIONS USED: Abatement Relocation Housekeeping Medical Therapy Education
FAMILY'S ATTITUDES, BELIEFS, AND BEHAVIOR (HBM): Motivation to avoid illness Perceived susceptibility to illness Perceived severity of illness Perceived barriers to compliance Perceived benefits to compliance Degree of self-efficacy

Table 2: Questions Used to Explain Attitudes, Beliefs, and Behavior Based on the Health Belief Model

HBM Category	Sample Question
1. Motivation to Avoid Illness	Will having check-ups help your child get better?
2. Perceived Susceptibility to Illness	Do you agree that your child could look and act healthy but still be sick?
3. Perceived Barriers to Compliance	Has keeping your child away from the lead been easy?
4. Perceived Benefits to Compliance	Do you agree that your doctor can make your child well when he/she is sick?
5. Perceived Severity of the Illness	Compared to other dangers to your child's health, do you think lead poisoning is more serious?
6. Measure of Self-efficacy	Do you feel that there are things you can do to help cure your child of lead poisoning?

Table 3: Short Definitions of Groups Based on Significant BLL Reductions

Study Group	Short Definition	Number in Group
Group A	Children in study group who had a BLL reduction > 10 ug/dl following intervention	21
Group B	Children in study group who had a BLL reduction <= 10 ug/dl following intervention	12
Group C	Children in study group who had their most recent BLL < 25 ug/dl	24
Group D	Children in study group who had their most recent BLL >= 25 ug/dl	9

Table 4: Comparison of Sample Interviewed to Remaining Study Group Based on Variables from Health Records

Variable	Frequency	
	Interviewed Sample	Uninterviewed Group
Source of Exposure	(n=14)	(n=16)
Paint/Soil Dust	72%	100%
Occupational	21	0
Other	7	0
Medical Treatment	(n=14)	(n=21)
Yes	29	29
No	71	71
Intervention Used	(n=14)	(n=18)
Abatement	29	0
Relocation	43	78
Housekeeping	29	22
Education	100	100
BLL Reduction:	(n=15)	(n=18)
Change > 10 ug/dl	80	33
Change <= 10 ug/dl	20	67
Latest level < 25 ug/dl	87	62
Latest level >= 25 ug/dl	13	38

Table 5: Number of Children Receiving Each Intervention and Frequency of Children in Each BLL Reduction Category

Intervention Used	No. Receiving Intervention	BLL Reduction Achieved	
		Group A	Group B
Abatement	4	100%	0%
Relocation	21	57%	43%
Housekeeping	8	63%	38%

5A: Children Receiving Intervention in Group A or B

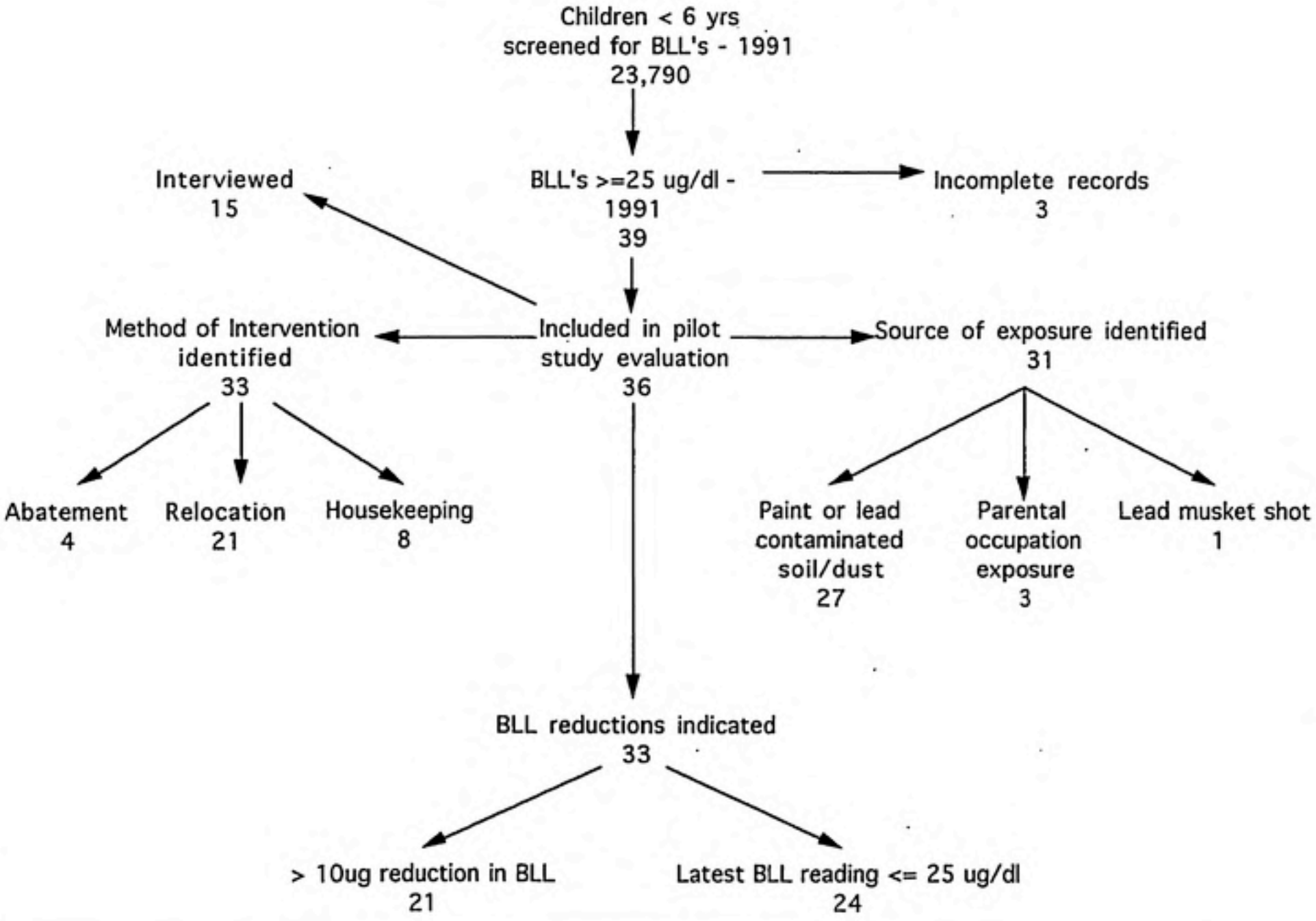
Intervention Used	No. Receiving Intervention	Latest BLL Achieved	
		Group C	Group D
Abatement	4	100%	0%
Relocation	21	71%	29%
Housekeeping	8	63%	38%

5B: Children Receiving Intervention in Group C or D

Table 6: Summary of Answers to Questions Assessing Knowledge of Lead Poisoning

Question and Correct Answer	Frequency Answering Correctly	
	Study Group	Comparison Group
Lead poisoning causes learning problems	n=14 85.7%	n=24 83.8%
Lead poisoning can cause death	n=14 100.0	n=24 58.3
Lead can cause head/stomach aches	n=14 71.4	n=24 62.5
Changing playing areas will help	n=14 71.4	n=15 45.8
Mopping is very helpful	n=10 80.0	n=24 29.2
Washing child's hands is very helpful	n=10 100.0	n=24 62.5
Covering cracked painted surfaces is not helpful	n=7 85.7	n=24 58.3
Sweeping chips to outside of house is not helpful	n=10 20.0	n=24 8.3
Melting down old paint is not helpful	n=7 57.1	n=24 20.8

Table 7: Flowchart Describing Children in Program



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APPENDIX A

North Carolina Department of Environment, Health, and Natural Resources
Division of Maternal and Child Health
P.O. Box 27687 • Raleigh, North Carolina 27611-7687

James G. Martin, Governor
William W. Cobey, Jr., Secretary

Ann F. Wolfe, M.D., M.P.H.
Director

N.C. CHILDHOOD LEAD POISONING PREVENTION PROGRAM EVALUATION INTERVIEW

NAME OF INTERVIEWEE_____
NAME OF CHILD_____

ADDRESS_____
_____

COUNTY_____
TELEPHONE NO._____

Hello, my name is Holly Bivins. As we have already discussed, I am a student at the University of North Carolina at Chapel Hill. I am evaluating North Carolina's Childhood Lead Poisoning Prevention Program. With your help, I hope to improve the program to help others.

I want to assure you that everything that you say will be held in the strictest confidence. I will summarize my findings in a report, but no individuals will be named.

Directions to home:_____
_____
_____
_____
_____

Other information:_____
_____
_____
_____
_____
_____

Today, I will ask you a series of questions about your experience with the Lead Program. Most of the questions can have just one-word answers, but if you would like to explain more, please do. The more information I get, the better.

The first set of questions focuses on how you learned that your child had lead in his/her blood and what information you received about children and lead.

1) I would like to know who talked to you about lead poisoning. Could you please answer "yes" or "no" to the following people if they discussed any lead poisoning information with you? (y=yes, n=no)

		Y	N
a.	a nurse	_____	_____
b.	an inspector who looked for lead	_____	_____
c.	a person who helped you remove lead from your house	_____	_____
d.	a doctor	_____	_____
e.	other_____	_____	_____

2) Do you remember a nurse or someone from the health department coming to talk to you about your child and lead? (i.e. a home visit)
   a. yes
   b. no
   IF NO, go to Q#4

3) Was this conversation:
   a. very helpful
   b. somewhat helpful
   c. not helpful at all
   d. not sure

   How much time do you feel these people spent with you explaining lead poisoning?
   a. too much time
   b. just the right amount of time
   c. not enough time

4) Do you remember receiving any pamphlets or brochures about lead poisoning?
   a. yes
   b. no
   IF NO, go to Q#5
   IF YES, Were these pamphlets or brochures:
      a. very helpful
      b. somewhat helpful
      c. not helpful at all
      d. not sure

5) Did anyone from the health department show you how you could keep lead away from your child?
a. yes
b. no
IF NO, go to Q#6
IF YES, was this
a. very helpful
b. somewhat helpful
c. not helpful at all
d. not sure

6) Compared to other dangers to your child's health, do you think lead poisoning is
a. less serious
b. as serious
c. more serious

7) Does your child spend a part of the day with someone besides you or at day-care?
a. yes
b. no
IF NO, go to Q#8
IF YES, does this person who takes care of your child know of the dangers of lead poisoning?
a. yes
b. no
c. unsure

8) I am now going to list some possible places where children could come in contact with lead. Please answer "yes" or "no" to the following places where you believe your child may have been in contact with lead.

	Y	N
a. in your house	_____	_____
b. in your yard	_____	_____
c. in a neighbor's house or yard	_____	_____
d. where you used to live	_____	_____
e. from where a parent works	_____	_____
f. other_____	_____	_____
g. not sure		

9) Before you had your child tested for lead in his/her blood, did you know about lead poisoning?
a. yes
b. no
IF NO, go to Q#10
IF YES, where did you learn about it?
a. a friend, relative, or neighbor
b. school
c. doctor or nurse at health department
d. doctor or nurse not at health department
e. T.V., newspaper, book, or radio
f. other_____
g. not sure

10) Now I am going to ask you a series of questions, and I would like to know whether you agree or disagree with them or are not sure. (A=agree, D=disagree, NS=not sure)

	A	D	NS
a. Lead can cause learning problems for your child.	___	___	___
b. Lead can cause hair loss.	___	___	___
c. Lead can cause death.	___	___	___
d. Lead can cause headaches and upset stomachs.	___	___	___
e. Changing the area where your child is allowed to play can keep your child from being lead poisoned.	___	___	___
f. The source of lead in your home is from:			
1. lead on walls	___	___	___
2. soil and/or dust	___	___	___
3. water or food	___	___	___
4. burning printed paper or painted boards	___	___	___
5. toys or play things your child puts in his mouth	___	___	___
6. other_____			

11. Please tell me if you think the following activities would be very helpful, somewhat helpful, or not helpful at all in keeping your child away from lead. (VH=very helpful, SH=somewhat helpful, NH= not helpful at all)

	VH	SH	NH
1. wet mopping the floor	___	___	___
2. washing your child's hands often	___	___	___
3. covering cracked painted surfaces	___	___	___
4. sweeping chips/dust to outside of house	___	___	___
5. melting down old paint	___	___	___

Now I would like to ask you a few questions about the inspection done by the State to find the lead.

12) Were you the person who was home when the inspection took place?
a. yes
b. no
IF NO, go to Q#15

13) Do you remember getting any information from the inspectors about lead in your home?
a. yes
b. no
IF NO, go to Q#14
IF YES, did you think this information was:
a. very helpful
b. somewhat helpful
c. not helpful at all
d. not sure

How much time do you feel these people spent with you explaining lead poisoning?

a. too much time
b. just the right amount of time
c. not enough time

14) Did the inspectors show you where the lead is/was in your home?
a. yes
b. no

15) Was the source of lead removed?
a. yes
b. no
c. not sure
IF YES, go to Q#16-Q#19
IF NO or NOT SURE, go to Q#20-Q#21

16) Who removed the lead?
a. you or your spouse
b. the landlord
c. other _____

17) Do you remember getting information about lead from any people who helped remove it?
a. yes
b. no
IF NO, go to Q#18
IF YES, was this information:
a. very helpful
b. somewhat helpful
c. not helpful at all
d. not sure

18) Did you stay somewhere else while work was being done on your home?
a. yes
b. no
IF NO, go to Q#19
IF YES, how easy was it for you to find somewhere to stay?
a. very easy
b. somewhat easy
c. not easy at all

19) Are you still living in the same house?
a. yes
b. no
IF YES, go to Q#22
IF NO, how difficult was it for you to find another house?
a. very difficult
b. somewhat difficult
c. not difficult at all
d. not sure
GO TO Q#22

20) I am going to read a list of possible reasons why the source of lead was not removed from your home. Please answer "yes" or "no" to the following reasons if they apply or do not apply in your situation:

		Y	N
a.	You are renting so you are not responsible	____	____
b.	The landlord has not abated (IF YES to b., skip to #16)	____	____
c.	It was too much money	____	____
d.	It took too much time	____	____
e.	You were not told how to do it	____	____
f.	You were not told you should do it	____	____
h.	It was easier to move	____	____
i.	Other _____	____	____

21) Are you still living in the same house?
a. yes
b. no

IF NO, how difficult was it for you to find another house?
a. very difficult
b. somewhat difficult
c. not difficult at all
d. not sure

GO TO Q#22

IF YES, Now I would like to ask you how you are handling the lead that is still in your home. The following activities could be done to reduce the amount of lead in you home. Could you please tell me if you do these activities "very often, "somewhat often", or "not often at all"?: (VO=very often, SO=somewhat often, NO=not often at all)

		VO	SO	NO
a.	You wet-mop	___	___	___
b.	You wash your child's hands	___	___	___
c.	You vacuum or sweep	___	___	___

Now I would like to know your opinion on some possible problems you might have in handling the lead that is still in your home. Do you agree, disagree, or are unsure about these statements?

		A	D	NS
a.	Keeping your child away from lead has been easy.	___	___	___
b.	Cleaning the house often interferes with other things you must do during the day.	___	___	___
c.	You often have many errands and chores you must do during the day.	___	___	___

GO TO Q#22

Now I would like to ask you a few questions about the medical treatment your child has received.

22) How did it happen that your child was tested for lead in his/her blood?
   a. it was done through Medicaid or EPSDT
   b. check-up or the health department scheduled you
   c. a doctor advised you to
   d. you decided on your own
   e. other_____

23) Where was your child screened for lead in his/her blood?
   a. at the hospital
   b. at the health department
   c. at a private doctor's office
   d. other_____
   e. not sure

24) Has your child ever been hospitalized because of his/her lead poisoning or has the doctor/nurse given him/her a pill for lead poisoning?
   a. yes
   b. no
   c. not sure

   IF YES, I would like to ask you some questions about this treatment. What is your opinion on the following statements? Please tell me if you agree, disagree, or are unsure about them.

	A	D	NS
a. It was difficult for you to get transportation to the hospital.	___	___	___
b. It was difficult for you to find the time for the appointments.	___	___	___
c. These treatments will definitely help my child get better.	___	___	___

25) I would like to ask you a few questions about taking your child for his/her check-ups to test for lead in his/her blood. What is your opinion on the following statements. Please tell me if you agree, disagree, or are unsure about them.

	A	D	NS
a. It is/was difficult for you to get transportation to the health dept.	___	___	___
b. It it/was difficult for you to make the time to go to all the appointments.	___	___	___
c. Having check-ups will definitely help your child get better.	___	___	___

Now I would like to ask you a few questions about your child's medical care in general.

26) Does your family have a regular doctor to go to?
   a. yes
   b. no

   IF NO, go to Q#28

27) Has your doctor told you about the dangers of lead poisoning?
   a. yes
   b. no

   IF NO, go to Q#28

   IF YES, the information your doctor gave you was
      a. very helpful
      b. somewhat helpful
      c. not helpful at all
      d. not sure

28) Do you feel that there are things you can do to help cure your child of lead poisoning?
   a. yes
   b. no
   c. not sure

29) Do you think that things you have done for your child already have helped him/her get better?
   a. yes
   b. no
   c. not sure

30) The following are some statements about medical care and your child. What is your opinion on these statements? Please tell me if you agree, disagree, or are not sure about them:

		A	D	NS
a.	Your doctor or nurse can make your child well when he/she is sick.	___	___	___
b.	If you wait long enough, your child will get over being sick on his own.	___	___	___
c.	Even if your child looked and acted healthy, he/she still could be sick.	___	___	___
d.	Your child gets sick very often.	___	___	___
e.	When your child gets sick, you usually take him/her to the doctor.	___	___	___
f.	Your child and the rest ot the family eat enough healthy meals.	___	___	___

I am asking these last questions to learn a little bit more about you. You do not need to answer these if you feel uncomfortable about them.

31) Are there any other adults here to help you around the house or with your child/children?
   a. yes
   b. no

32) How many children live in this home?_____

33) How many of these children are under 6 years old?_____

34) How many of these children have been screened for lead?_____

35) Do you have medical insurance?
   a. yes
   b. no
   IF YES, what medical insurance do you have?
      a. Medicaid
      b. private insurer
      c. not sure

36) What is the last grade of school which you completed?
   a. elementary school
   b. high school
   c. college
   d. graduate school

37) Please give the letter which corresponds closest to your total household income:
   a. less than $9,999
   b. $10,000 to $14,999
   c. $15,000 to $19,999
   d. $20,000 to $29,999
   e. $30,000 or more

That completes all my questions. Now I want to give you the chance to tell me anything else about your experiences with the Lead Program and the health department. The more information I have, the better I will be able to understand what exactly goes on with the families involved in the Lead Program. So, is there anything else you would like to discuss with me?

Thank-you very much for participating in this project and taking time out to talk with me. I really appreciate your help and am looking forward to using this information to improve the program. If you have any questions, please call your local public health nurse. Thank-you again and good-bye.