A Comparison of Settled Dust Lead Test Kits When Used By Consumers and Trained Professionals

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Summary

Goal The overall goal of the project is to compare the performance of trained and untrained individuals in the use of field kits for settled dust lead testing.

Description With advice from an expert panel, the National Center for Healthy Housing (NCHH) developed a dust lead testing kit, which was designed to provide easy-to-use instructions and materials. A grading system was used to determine the performance of five certified lead inspectors and five certified risk assessors when using the kit. The same grading system was used to evaluate the performance of 25 untrained homeowners and 25 untrained rental property owners/managers in using the kit. These target groups were selected because they represent likely users of consumer-based dust testing kits and because they vary in terms of education, motivation, and knowledge of lead issues. The proficiency of the untrained participants was compared with the proficiency of the trained and certified lead professionals. The grading system assessed four different aspects of lead dust sample collection: floor sample collection, windowsill sample collection, completion of the sample collection form, and interpretation of laboratory results.

Results The untrained homeowners and property owners performed at least 90% as well as the trained participants in three of the four assessment components: floor sample collection, completion of the sample information form, and interpretation of laboratory results. However, the untrained personnel performed more poorly for windowsill sample collection.

A higher education level and some prior experience with lead dust testing were two factors related to higher performance scores. Participants who had a Master's or Bachelor's degree or had some college courses scored significantly higher than those with a high school degree or fewer years of school. The untrained participants who were less successful in their performance may have benefited from instructions that included clearer images and definitions of the components and sample areas. Participants who were not trained but had some prior experience with lead dust testing, including having their homes tested for lead dust, or observing or implementing a lead dust test, also scored significantly higher.

Windowsill sampling proved more challenging for study participants than the floor sampling procedure. The criterion for measuring the dimensions of the windowsill surface dust sampling area, especially the width, to within 1/8 of an inch, was difficult for most to achieve. This small error in the width of the windowsill may adversely affect the test result, particularly in the case where levels of lead are close to the EPA standard.

The use of a pre-measured template prevented this error in the floor sampling procedure, but exposed a different issue for home test kit design. A small subset of the untrained participants did not understand what the word "template" referred to, and so did not use the template at all or used it incorrectly. Terminology was also a problem in the windowsill sampling procedure. Some participants sampled the window well instead of the windowsill area. This is a significant error given that the difference between lead dust loading results for interior windowsill and window wells can be very large.

Conclusion The study demonstrated that untrained users can collect lead dust samples almost as well as trained users when the kit is designed for use by individuals unfamiliar with the lead dust sampling procedure, with the exception of interior window sills.

INTRODUCTION

Renovation and remodeling activities generate large quantities of dust and can transform intact lead-based paint into hazardous settled lead dust, unless proper work practices are used.[1] (All references to "lead dust" in this report refer to that which settles on horizontal surfaces such as floors and window sills, not that which is airborne.) A wipe-sampling test, which should be performed after paint disturbing activities and cleanup is finished, determines if lead dust is present at levels that pose a health risk and whether additional cleaning or other hazard control actions are needed to ensure the dwelling is safe for children.[2] Typically, certified lead inspectors, risk assessors, and in some jurisdictions other trained personnel, collect lead dust samples by this wipe-sampling method. However, home and rental property owners may choose to not use such individuals and may want to perform their own test, or perhaps opt not to test their homes for lead dust hazards. Some environmental lead laboratories offer home lead dust testing kits, but these kits are useful only if the person using the kit can produce an accurate result and correctly interpret the findings. The purpose of this study was to outline what should be in a dust lead test kit to help make it suitable for homeowners and property managers, and to if untrained users can perform lead dust testing adequately using an example of such a dust lead test kit.

An EPA study in 1997 assessed the amount of disturbance and potential exposure to lead resulting from selected renovation and remodeling activities. With the exception of carpet removal and drilling into plaster, all activities monitored in the study deposited significant amounts of settled lead dust.[1] Renovation and remodeling activities that disturb lead-based paint are currently regulated only in federally assisted housing units and in some local jurisdictions,[3] although EPA has recently issued a proposed rule to regulate certain painting, renovation and remodeling work.

Dust lead loading ($\mu g/ ft^2$), collected by wipe sampling method, is better correlated with children's blood lead levels than is dust lead concentration ($\mu g/g$) collected by vacuum methods.[4] Using the same dust collection method, the relationship between children's blood lead levels and the type of surface in the home where it was collected (floor, windowsill, or window well) was different. For this reason, EPA set different standards for dust lead loadings for floors, interior window sills (and for clearance only, exterior window wells). To pass clearance, dust lead levels tested by wipe sampling must be less than 40 µg/ft^2 for interior floors, 250 µg/ft^2 for interior windowsills, and 400 µg/ft^2 for window troughs.[5]

Wipe procedures have been used by industrial hygienists and others for many years to evaluate surface contamination by various toxicants. The first description of a technique for wet wipe sampling of lead on residential surfaces containing dust lead was published in 1974.[6] HUD, ASTM, NIOSH, and EPA have developed protocols for the collection of lead dust samples [7]. All describe a technique of passing the wipe across a defined sample area two times, once side to side and again top to bottom. While the ASTM method requires a third pass around the perimeter of the sampling area, only the HUD method has been correlated with children's blood lead levels. Some professionals believe that the third pass called for in the ASTM standard is not significantly different from the HUD method. The procedure for lead dust sampling is simple, but results are sensitive to variations in technique and individuals are likely to have varying aptitudes for understanding and following instructions. The purpose of this study is to determine whether individuals with no prior training can use a lead dust test kit, follow the instructions, and perform reasonably simple collection procedures and interpretation.

METHODS

Project Overview

We conducted this study in five phases. First, we developed a home lead dust kit and we enlisted a group of experts to assist in its development. Samples of commercially available home lead dust test kits were obtained. The Center based decisions about the components to include in the kit and the content and presentation of the instructions on a review of existing home test kits and on recommendations from the panel of experts.

Next, performance tools were developed. The Center created grading forms to evaluate four aspects of lead dust sample collection, including (1) collecting the floor sample; (2) collecting the windowsill sample; (3) completing the sample information form; and (4) understanding laboratory results. Enrollment forms were also created to collect demographic information about the trained and the untrained participants. We conducted a pilot test using the model kit and assessment tools, and made adjustments to the kit and grading forms based on feedback from the graders and participants.

Third, we assessed the performance of the certified risk assessors and lead inspectors. This established a baseline of performance to use as a point of reference for comparison with the lay peoples' ability to collect lead dust samples. An "on-site grader" was at the testing facility and evaluated the participant as they collected the samples. Two other graders evaluated each participant from a videotape that was made as each performed the test.

The fourth phase was the assessment of the performance by the target users, homeowners and property managers using the model kit and assessment tools. The on-site grader and two video graders who scored the trained group of participants also evaluated this untrained group.

The last phase of the study was the analysis of the data to test this hypothesis for the four individual test components and overall performance. We established a target quality objective to determine if the target users could perform lead dust testing at least 90% as well as the trained professionals.

Development Of Model Dust Test Kit

Review of Existing Kits and Summary of Commercial Kit Components

In the spring of 2001, we identified eight laboratories that offered home lead dust test kits from a list of environmental lead laboratories. Each of these laboratories supplied a kit to us. The kits all contained similar components (tubes, disposable gloves, and wipes), but the presentation of the materials and instructions varied. Some kits were formal products marketed for home testing. Other laboratories provided the necessary components and instructions upon request, but did not have a home test kit product.

<u>Wipes</u>. All of the sample kits included wipes for collecting the samples. Three of the kits used Wet Nap™ brand wipes, three included Ghost™ wipe brand wipes, one used Pace™ brand wipes, and one used the MediPak BZK towelette. The quantity of wipes included in the kits also varied. Four kits supplied two wipes per kit. Three of the kits supplied one wipe per kit. One kit included 12 wipes.

<u>Sample Containers</u>. Conical 50 ml centrifuge tubes were included as components of six of the eight kits. Three of these kits provided a type that had a flat base. One laboratory provided a flat-based tube that was not a conical centrifuge tube for the sample collection tube. Another supplied zip-lock plastic bags (which are not permitted by the HUD Guidelines due to the difficulty in quantitatively removing all lead dust from the plastic bags).

Disposable Gloves. Seven of the eight sample kits included disposable gloves. Five were plastic and two were latex. The eighth did not include gloves.

Laboratory Form. All of the laboratories provided some type of sample information or chain-of-custody form with their kit. One laboratory presented the sample information sheet as part of a questionnaire since they were a partner in a research project collecting additional information. The different forms were partly related to the number of sample types and toxicants for which the forms were used. Not surprisingly, the forms that requested only information about lead dust wipe samples had simpler forms.

Instructions. Seven of the eight kits included instructions for collecting the sample, with the presentation and amount of detail in the instructions differing greatly. Three of the instructions gave some detail in the protocol for the sample collection procedure. Five of the seven kit instructions used a diagram or illustrations. Three laboratories did not distinguish a difference in the method for collecting different types of samples (floor, windowsill, window well). Four of the seven laboratories gave some guidance about where in the home the sample should be collected. Two laboratories included general information about lead hazards along with the sampling protocol.

Mailer. Four of the sample kits provided a mailer for returning the sample to the laboratory.

Template. Only one laboratory included a template as a component of their kit. The template measured 10 cm x 10 cm. Another laboratory offered a reusable plastic 12 inch x 12 inch template as a separate product. The additional cost to purchase this template was thirty dollars.

Review Panel Recommendations and Center Decisions on Test Kit Components

The test kit used in this study was designed to facilitate the collection of field lead dust samples by the two groups of target users participating in the study (homeowners and property managers). The Center assembled a group of experts to serve as a review panel in developing the model kit for the study and to assist in various aspects of the project. The panel included experienced risk assessors, lead training providers, and lead analysis laboratory managers.

Wipes. Two review panel members, both lead analysis laboratory managers, felt that it was important to use wipes that dissolved easily (e.g. Ghost™ wipes or Pace™ Wipes) during laboratory analysis. These wipes may make the wipe digestion process in the laboratory simpler and produce more quantitative recovery rates. The risk assessors on the panel suggested a larger, heavier wipe, because it would be less likely to tear or degrade during sample collection. During the same time of this study, the American Industrial Hygiene Association issued recommendations that lead dust testing should be performed using wipe media that conform to the ASTM standard E1792-03. We chose to use Wet Nap™ wipes for the purpose of this study, because certified risk assessors and lead inspectors typically use a larger type wipe, and their experience and performance form the baseline of the study.

Tubes. All of the review panel members agreed that 50 ml conical centrifuge tubes should be included in the model kit because the digestion blocks in environmental lead laboratories are set up for this type of centrifuge tube. When a different container, (e.g. a plastic bag) is used, the laboratory technician has to transfer the sample to a 50 ml conical tube. This transfer increases the chance of sample loss or contamination and it is unlikely that quantitative transfer of lead dust can occur if the wipe is housed in a baggie. Several panel members suggested using a flat-bottomed conical tube so the kit user could set the tube upright during sample collection without having to use a holder.

Gloves. All panel members agreed that the disposable gloves for the model kit needed to be loose fitting and easy to put on and remove.

Template. The review panel felt that a floor template would help the kit user collect the sample from an accurately measured area, but recognized that it could add significant cost to the kit. A paper 12 x 12 inch template cut from poster board was designed for the study that was relatively inexpensive to produce and could fold into a compact shape.

Kit instructions. Two different points of view emerged during discussions about the kit instructions. One viewpoint held that the instructions should be rudimentary, such as simply telling the sample collector to mark off an area on the floor and wipe it completely. This viewpoint felt that the benefit of providing a simple procedure would outweigh the risk of obtaining an inaccurate result. In some of the commercially available kits, much more detailed directions were given, such as telling the sample collector how to avoid contaminating the sample by inadvertently touching the wipe or their hands to other surfaces in the room.

Some panel members felt that the instructions needed to follow a standardized method for lead dust sample collection (e.g. HUD or ASTM protocol) because a standard method ensures that all lead dust samples are collected in a similar way and the standard method has been correlated with children's blood lead levels. Training for certification of lead inspectors and risk assessors includes learning this sample collection technique, and the current EPA standards for acceptable levels of lead dust are based on studies that used this method of sample collection. Variations in collection techniques result in significant differences in the amounts of lead measured and therefore the ability to predict risk to children. We decided to follow the ASTM protocol for the model kit instructions, because a standard protocol should be followed for all lead dust sample collection. We also decided to include illustrations. The Center designed the instructions so the participant could open the instructions, place them on the floor, and easily read each step without having to turn pages. Additional information about lead-based paint hazards was also included.

Data Collection Instruments

Data collection forms were developed to document such errors as cross-contamination of samples, failure to measure surface area correctly, failure to prepare the surface by taping the template or window sill, failure to contact the entire surface area with the wipe media, incorrect documentation of the type of surface (floor or window sill), and inaccurately labeling sample container tubes. Grading forms 1 and 2 concentrated on these areas, while grading form 3 (lab form submission) documented how accurately and completely the participant filled out the field data collection form.

Enrollment forms

We developed separate enrollment forms for the trained and untrained study participants. Certified inspectors and risk assessors were asked to provide information about their training and amount of experience in collecting lead dust samples. The enrollment form for lay people gathered data about experiences with lead dust testing and the age of their home. Both enrollment forms requested general demographic information about gender, race, and education.

Assessment System

The Center considered three aspects of the lead dust collection process when creating the grading system for the study: sample collection, submission of information to the laboratory, and interpretation of lab results. The assessment system consisted of four grading forms. Grading form 1 was used to evaluate the ability of the participant to collect the floor sample. Grading form 2 assessed their windowsill sample collection technique. The participant's ability to fill out the sample information form was assessed on grading form 3. Grading form 4 was a ten question multiple choice and fill-in-the blank questionnaire that examined the participant's ability to correctly interpret the lab results.

The final step in the lead dust testing process takes place when an individual receives the lab results. Grading form 4 (understanding laboratory results) evaluates the participant's ability to correctly interpret the results of the lab analysis, which includes an understanding that lead in dust is potentially hazardous, whether results are above or below applicable EPA standards, and the importance of recommending corrective action if results are above the standards. It was beyond the scope of this study to evaluate which corrective actions were best.

Selection and Weighting of Grading Criteria

Each step was broken down into sub-actions that could be observed and evaluated by the graders. We assigned each of these grading criteria a numerical value, based on the relative importance of the criteria to the outcome of the results. The grading forms for completing the lab submission form (Grading Form 3) were weighted equally. The ten questions in Grading Form 4 that assessed a participant's ability to understand lab results were all given equal weight.

We considered the floor and sill sampling grading forms more important in the overall score, because if the sample was collected incorrectly, filling out the form correctly and interpreting the results correctly would still give an incorrect result. Grading forms 1 and 2 totaled 100 points each, and grading forms 3 and 4 were 50 points each. Therefore, the maximum overall score for each participant was 300 points.

The flooring used for evaluating collection of floor samples was new linoleum flooring, instead of a worn wood floor, because the objective of the study was not to evaluate participants under the most challenging sampling conditions. After experimenting with several different types of gloves, we found that nitrile gloves fit snugly and made handling the wipe easier.

Experience Of Professionals With The Dust Test Kit

Recruitment of Professional Participants

We identified the population of trained participants using a list of certified inspectors and risk assessors in the Baltimore MD area. Each certified lead inspector or risk assessor on the list was assigned a number. We attempted to contact each individual certified risk assessor or lead inspector three times. After three attempts were made to contact each professional on the list, three additional participants were needed to meet the goal of ten certified participants for the study. We recruited these three additional participants from the companies employing the two video graders. Two of the scheduled trained participants did not come to the testing site, resulting in 8 professional participants.

Testing of Professionals' Performance

Of the eight trained participants who took part in the study, two were certified lead inspectors and six were certified risk assessors. Participants arriving at the testing facility were given a model kit and encouraged to look over the directions and the kit components. Each participant completed an enrollment form. The participants were given the opportunity to ask questions about the kit and procedure. This stage of the process took place in a separate room from where the testing activities were conducted so that arriving participants did not have the opportunity to observe the sample collection procedure.

The videographer set up the camera on the opposite side of the room from where the on-site grader sat. The objective of this arrangement was to allow the video graders to view the participant's activities when the on-site grader could not.

The on-site grader instructed the participants to perform the test as if they were collecting the sample in a home. After the participant collected samples from the floor and sill and completed the lab submission form, the on-site grader took the form and sample collection tubes from the participant. The dimensions of the windowsill sampling surface area were checked, and Form 3 was completed, based on how the participant filled out the lab submission form. The participant was given a 10-question, multiple choice and fill-in-the-blank questionnaire (Form 4) to complete and were permitted to refer to the kit instructions to answer the questions.

The video graders observed the videotapes of the certified risk assessor and inspectors performing the testing and completed grading form 1 and grading form 2 for each participant. Both video graders viewed the tapes at the same time and were permitted to rewind and watch the performance of each participant as many times as they felt was necessary.

Experience Of Lay People With Dust Test Kit

The Coalition to End Childhood Lead Poisoning (Baltimore, MD) conducted the recruitment of the property managers and homeowners for the study. Homeowners were recruited by distributing flyers at community training events conducted over a one-week period.

Other contacts with homeowners came through an email sent to the organization's key partners. A fifty-dollar incentive was offered to both the property managers and homeowners to take part in the study. Individuals interested in participating in the study selected a time slot to come to the testing site. Directions to the testing facility and a copy of the kit instructions were mailed to each scheduled participant. Each homeowner and property manager was asked about their experience, if any, with lead dust sampling.

Forty-seven untrained participants took part in the study, including 35 homeowners, 9 property managers, and 3 who did not specify a category. The testing area was set up to reproduce the site used for the trained participants. When participants arrived at the testing facility, they were given the model kit and asked to look over the directions and the kit components. Each participant completed an enrollment form. The participants were given the opportunity to ask questions about the kit and procedure. This stage of the process took place in an area that was separate from where the testing activities were conducted so that arriving participants would not be able to see the sample collection procedure prior to their evaluation.

Participants were asked to perform the test as if they were collecting the sample in a home. After the participant collected samples from the floor and sill and completed the lab submission form, the on-site grader took the form and sample tubes from the participant, checked the windowsill measurement, and completed Form 3 based on how the participant filled out the lab submission form.

Participants completed a ten question, multiple choice and fill-in-the-blank questionnaire (Grading Form 4). They were permitted to use the kit instructions to answer the questions.

The video graders viewed the videotapes of the lay people collecting the samples and completed grading form 1 and grading form 2 for each participant. The video graders observed the tapes at the same time. They were permitted to rewind and watch the performance of each participant as many times as they felt was necessary.

Data Management And Quality Control Procedures

Test for Bias in Grading

One concern in the assessment system was that the graders might have a tendency to grade participants differently based on whether they were trained or untrained. Since all the graders were certified risk assessors, they might have a bias in favor of the trained participants.

On the other hand, knowing that the participants had no prior experience in collecting lead dust samples, they could be more lenient in how they judged the performance of a layperson.

Five sampling technicians participated in a test to check for bias in the grading based on whether the participants were trained or untrained. The Center presented two of the five participants to the on-site grader and the two video graders as the first two untrained participants. The graders were blinded to the status of the participants in order to reduce this source of bias.

Data collection and management

Collection of participant files and videotapes. Once each participant completed the testing protocol, we collected the six forms and placed them into a separate file for each participant and checked for missing entries. The six forms making up each participant file were the enrollment form, a completed sample collection form, and Grading Forms 1, 2, 3, and 4 completed by the on-site grader. Forms were checked for missing information and added to each participant's file.

Data Entry. The data for each participant was entered into Excel spreadsheets.

Quality Assurance Review

The Quality Assurance Manager for the project compared the data in the Excel spreadsheets with the grading and enrollment forms in each participant file and noted any discrepancies or errors. Corrections were made to the data files as needed.

Data Analysis

The data were analyzed using SAS software. Descriptive statistics were generated for results from the three different graders, the four separate grading forms, and an overall grade. Nested models were used to examine differences in scores due to grader, group (trained or untrained), and test components (1, 2, 3 or 4). The Center examined the frequency and type of errors made by both the trained and untrained participants. A t-test was used to test if there was a significant difference in the mean score for the untrained participants and 90% of the mean score for the trained participants for the four test components and the overall score. The Center performed a multiple regression analysis to determine if participant demographics accounted for some of the variability in the data.

RESULTS

Correlation of the Scores from the Three Graders

The evaluators first looked at the influence of grader on the performance assessment. Grader 1 was physically present during all of the testing, while Graders 2 and 3 graded by watching video tapes of the participants' performance. Grader 1 completed Forms 1, 2, and 3. Graders 2 and 3 completed only Forms 1 and 2. Form 4 was a multiple choice fill in the blank questionnaire graded only by the NCHH staff member at the test site and not by the three observers.

The evaluators developed a nested model to determine if the scores for Form 1 and Form 2 were dependent on the grader, the group (trained or untrained), and/or the interaction of these two variables. The model contained a random effect term to control for multiple graders and forms (1 and 2) for each person. The model results showed that for both Form 1 and Form 2 the grader and group by grader interaction is not significant ($p=0.16$, and 0.29, respectively). This indicates that the scores are the same for the three graders, and subsequent analyses were conducted using only the on-site grader scores. The on-site grader was able to provide data that were more complete because he could adjust his position to see all of the participants' actions, while the video remained in a fixed location. The video graders frequently could not see segments of a participant's performance, and were unable to score parts of the grading forms.

Performance of Certified Risk Assessors and Lead Inspectors

The mean score of the trained participant for the floor sampling was slightly lower than for the other three test components (Table 1). The most frequent deviations from the protocol made by the trained participants in the floor sampling procedure were the following: not having the wipe fully open for the first pass across the sampling area; not keeping the wipe flat during the first pass; not folding the contaminated part of the wipe inwards before the second and third passes; and using an incorrect motion for the second pass (Table 2).

Inaccurately measuring the windowsill sample area was the most frequent deviation made by the trained participants. Thirty-three percent of the trained participants did not meet the criteria of measuring to the nearest 1/8 of an inch for this step. Other deviations in the windowsill sampling procedure included not folding the wipe so that it fit on the windowsill for the first pass, not using a side-to-side motion for the first pass across the sill, and not folding the contaminated side of the wipe inward before taking the second pass with the wipe.

In general, the trained participants did not have problems completing the sample information form for the laboratory (Form 3) or interpreting the lab results (Form 4). The few errors made were related to inaccurate recording of the room location where the samples were collected. Perhaps mostly alarmingly, the most missed question in Form 4 asked what actions should be taken if the laboratory results showed lead levels above the EPA standard. Several of the trained participants responded that one should wait a month and then test the dust again. The correct response was to immediately test the children (if any) in the home for elevated blood lead levels and to clean up the lead-contaminated dust.

Table 1: Summary of Trained Participant Scores

Test Component	N	Mean	Median	Min	Max	STD
Floor Dust (Form 1)	9	92	95	75	100	10
Sill Dust (Form 2)	9	94	95	84	100	5
Lab Form Submission (Form 3)	9	96	100	80	100	9
Lab Form Interpretation (Form 4)	9	96	100	90	100	5
Weighted * Average Forms 1-4	9	93	98	80	100	7

* Form 1 (100 points) and Form 2 (100 points) are given twice the weight of Form 3 (50 points) and Form 4 (50 points).

Table 2: Most Frequent Deviations Made by Trained Participants

Test Component	Error				
Floor Sampling	*Wipe not fully open on 1st pass*	*Wipe not flat to floor on 1st pass*	*Contaminated side not folded in before 2nd pass*	*Incorrect motion for 2nd pass*	*Contaminated side not folded in before 3rd pass*
# incorrect / N	2/9	2/9	2/9	2/9	2/9
Windowsill sampling	*Incorrect measurement of sample area*	*Wipe hands over sill edge in 1st pass*	*Incorrect side-to-side motion on 1st pass*	*Contaminated side not folded in before 2nd pass*	*Sample area marked incorrectly*
# incorrect / N	3/9	2/9	2/9	2/9	1/9
Lab Form Submission	*Template measurement recorded incorrectly*	*Sill sample area recorded incorrectly*			
# incorrect / N	1/9	1/9			
Lab Form Interpretation	*Incorrect action if levels are above the EPA standard*	*Responded that test gives reliable info about past and future lead levels*	*Incorrect answer for EPA standard for floor dust lead*		
# incorrect / N	2/9	1/9	1/9		

<u>Performance of Untrained Participants</u>

Forty seven lay people participated in the study. One participant was physically unable to collect a floor sample, but completed the other three testing components. The untrained groups scored highest on Form 4, interpreting lab results, with a mean score of 85%. The mean score for windowsill sample collections (Form 2) was lowest at 68% (Table 3).

Table 3: Summary of Untrained Participant Scores

Test Component	N	Mean	Median	Min	Max	STD
Floor Dust (Form 1)	46	74	85	16	100	25
Sill Dust (Form 2)	47	68	79	11	92	23
Lab Form Submission (Form 3)	47	74	80	0	100	32
Lab Form Interpretation (Form 4)	47	85	90	40	100	14
Weighted* Average Forms 1-4	46	74	83	21	96	21

* Form 1 (100 points) and Form 2 (100 points) are given twice the weight of Form 3 (50 points) and Form 4 (50 points).

Frequent deviations made by the untrained participants while collecting the floor sample included the following: using an incorrect S motion in the second pass, touching other objects in the room with the hand that is folding the wipe, using the wrong amount of pressure for the 3rd pass with the wipe, touching or otherwise disturbing the sample area when laying the template, and not folding the contaminated side of the wipe inward before performing the third pass (Table 4).

Accurate measurement of the windowsill sample area was a particular area of difficulty for the untrained participants. Ninety-six percent of the participants did not measure the windowsill sample area to within 1/8 of an inch. Sixty-two percent of the participants marked the area incorrectly. Other deviations included letting the wipe hang over the windowsill edge on the first pass, not wiping the outer edges in the third pass, and crossing the sample area boundary in the third pass.

The untrained group had more difficulty than the trained group in completing the sample information form. Forty-seven percent did not fill out the sample information form completely. Other errors included incorrectly recording the room location of the windowsill and floor samples, incorrectly recording the measurement of sill sample area, and not writing in a clear and legible way.

Table 4: Most Frequent Deviations Made by Untrained Participants

Test Component	Error				
Floor Sampling	*Incorrect motion for 2nd pass*	*Hand folding wipe touched other objects*	*Incorrect pressure used in 3rd pass*	*Sample area disturbed when laying template*	*Contaminated side not folded in before third pass*
% incorrect	60	50	38	36	36
Windowsill sampling	*Incorrect measurement of sample area*	*Sample area not marked correctly*	*Wipe hung over sill edge in 1st pass*	*Outer edges of sample area are not wiped in 3rd pass*	*Wipe crosses sample boundary area in 3rd pass*
% incorrect	96	62	49	47	45
Lab Form Submission	*Form is not filled out completely*	*Location of sill sample not recorded*	*Location of floor sample not recorded*	*Sill sample area recorded incorrectly*	*Information not legible*
% incorrect	47	45	33	28	21
Lab Form Interpretation	*Responded that test gives reliable info about past and future lead levels*	*Incorrect EPA standard for floor lead dust*	*Incorrect EPA standard for windowsill lead dust*	*Incorrect response to rooms where samples should be collected*	
% incorrect	57	23	21	11	

Assessment of quality objective for untrained participants.

The quality objective for the untrained participants was that they score at least 90% of the baseline score of the trained participants. This objective was tested using a two sample t-test (Table 5). The untrained participants succeeded in meeting the objective of 90% of the trained participant score for three of the individual grading sections, floor sampling ($p = 0.138$), completing the sample collection form ($p=0.128$), and lab form interpretation ($p=0.423$). They did not perform 90% as well in the window sill sampling assessment (p=

0.021). The results show that overall, when summing the four separate parts of the grading system, the untrained participants did perform 90% as well as the risk assessors and lead inspectors ($p=0.062$), although the difference did approach significance of $p<0.05$. The marginal difference in the total score is a result of the untrained performance on the window sill sample collection component.

Table 5: Difference between Mean Untrained Score and 90% of Mean Trained Score

Test Component	Trained (N)	Untrained (N)	Mean Score Trained Participants	90% of Mean Trained Participants	Mean Score Untrained Participants	P-Value
Form 1: Floor sampling	9	46	92.3	83.1	73.8	0.138
Form 2: Windowsill sampling	9	47	94.0	84.6	68.4	0.021
Form 3: Lab Form Submission	9	47	95.6	86.0	73.6	0.128
Form 4: Lab Form Interpretation	9	47	95.6	86.0	85.1	0.423
Forms 1-4 Weighted* Average	9	46	94.0	84.6	73.8	0.062

* Form 1 (100 points) and Form 2 (100 points) are given twice the weight of Form 3 (50 points) and Form 4 (50 points).

Relationships Between Scores of the Four Test Components

We used a nested model to determine if trained and/or untrained participants score better on some components of the test than others. The model contained a random effect term to control for multiple test components for each participant. The interaction between participant group (trained or untrained) and test component (1, 2, 3, or 4) was not significant (p=0.29), and was dropped from the model. However, the participant group and the test component were significant predictors (p=0.004 and $p < 0.0001$ respectively) of performance.

The trained participants were expected to score 19% higher than the untrained participants while controlling for the test component part (trained = untrained + 19%). Both groups were expected to score highest on Form 4, laboratory result interpretation. Floor sampling (Form 1) and sample information form completion (Form 3) had expected scores 10% lower than Form 4, and window sill sampling (Form 2) had an expected score of 14% lower than Form 4. Forms 1 to 3 were not significantly different (p=0.24), but the performance on part 4 was significantly different from Forms 1 to 3 (each p=0.001).

Distribution of scores for trained and untrained participants

A comparison between the distributions of scores shows a substantial difference in the range of scores for the trained and the untrained participants (Fig. 1). The range of scores for the trained group is narrower in all cases, forms 1-4 and overall score suggesting that trained individuals have a higher degree of precision. The range of scores is broader for the untrained group with low score outliers in all cases. Median scores were lower for the untrained group for all test components (Forms 1-4) and for the weighted average overall score. The greatest difference in the median score was for Form 2, windowsill sampling, with the trained group having a median score of 95 and the median untrained participant score of 79.

Analysis of Demographic Variables for Untrained Participants as Indicators of Success

Eight demographic variables were analyzed as possible predictors for the outcome of the overall test score. (Table 6)

Table 6: Demographic and Other Variables

Gender (male/female) **Race** (black, white, Hispanic, other) **English is the native language** (yes, no) **Home was built before 1980** (yes, no) **Home or rental unit has been tested for lead dust** (yes, no) **Years of Education** (HS or less, college not BS, Bachelors or Masters degree) **Participant collected the lead dust sample in their home** (yes, no) **Participant observed lead dust sample being collected** (yes, no)

Gender. Seventy-one percent of all the untrained participants were women. A two sample t-test identified a marginal difference in the scores between the men and women participating in the study ($p=0.087$). The average overall score was 72% for women and 83% for men.

Race. Seventy-eight percent of participants were black, 18% were white, 2% were Hispanic, and 2% were other. Based on a two-sample t-test, there is a significant difference between scores of black and whites ($p=0.002$). Whites scored an average of 90% and blacks an average of 71%.

English as a native language. All participants spoke English; no analysis was done.

Years of Education. Twenty-four percent of participants had a high school education or less, 54% have some college but not a Bachelor's degree and 22% have a Bachelor's or Master's degree. Based on an ANOVA, level of education had a significant effect on score ($p<0.001$). Participants with some college experience but not a Bachelor's degree and those with either a master's or Bachelor's degree were marginally significantly different ($p=0.08$). Comparisons between the other two groups, high school compared with Masters or Bachelor's and with some college were significantly different (each $p<0.01$).

Home or rental unit built before 1980. Eighty-nine percent of the participants live in homes built before 1980. Based on a two-sample t-test, there is no significant difference between scores of participants that live in pre-1980 and post-1980 homes ($p=0.33$).

Home or rental unit has been tested for lead dust. Thirty percent of the participants had previously had their home or rental unit tested for lead dust. Based on a two-sample t-test, there is a significant difference between scores of participants that have had dust testing and those that have not (p=0.051). Those with dust testing had an average of 82% while those without had an average of 72%.

Observed or collected dust sample. Of the 14 participants that had their property tested for lead dust, one participant had collected the sample and six had observed the dust sample collection. Based on a two sample t-test, there is a significant difference between scores of participants that observed or implemented dust testing and those that did not (p=0.007). The average score for those that did was 88% and 73% for those that did not.

Test for Bias in Grading Trained vs. Untrained Participants

The evaluators conducted a test for bias in scoring based on the grader's knowledge of the participant being part of the trained or untrained group. Four trained sample technicians participated in the experiment. The testing of all four of the sample technicians took place on the same day. Two sample technicians were presented to the graders as untrained.

A nested model was developed to determine if the score depended on the grader, the group (participant presented at trained or as untrained), and/or the interaction of these two variables. A random effect variable controlled for multiple graders for each person. None of the variables were statistically significant. For part 3 and part 4 a simple ANOVA was run based on the on-site grader's scores by group. Group was not a significant predictor of score for parts 3 or 4. These results indicate a lack of bias by the graders based on participant group.

DISCUSSION

The results of this study demonstrate that average untrained individuals are able to collect floor and windowsill lead dust wipe samples in a way that is not significantly different from trained individuals if they are provided with proper instructions. Nevertheless, the trained individuals received a consistently higher score among the tested components, although this difference was not always statistically significant. Thus, there is likely to be some value in using trained individuals, all other things being equal.

The artificial setting of the test site contributed to some limitations for the study. In arranging the test site, the evaluators attempted to replicate a real world situation where a person would be collecting lead dust samples. However, each participant was under the scrutiny of the on-site grader and was also aware that video cameras were taping their performance. The on-site grader and NCHH staff tried to create a relaxed atmosphere, but some participants clearly felt nervous. The linoleum floor that was used to replace the worn wood created a floor on floor arrangement that was confusing to some participants. The participants followed the protocol of collecting lead dust samples, but the motivation to determine if their families or tenants were at risk for exposure to lead present in a real test situation was likely missing.

An analysis of the individual test components and errors identified weak areas in the performance of the untrained participants. Windowsill sampling proved to be a greater challenge than the floor sampling procedure. The criterion for measuring the windowsill, to within 1/8 of an inch, was difficult for most of the untrained participants to achieve. However, small errors in the measured size of the windowsill may become important when they are multiplied over the length of the sample area, and may affect the test result, particularly in the case where levels of lead are close to the EPA standard. A contributing factor to this problem may have been the beveled edge of the windowsill. Many participants included this edge in the measurement of the width of the windowsill, even though the area sampled was the flat surface of the windowsill. It would appear to be useful to include a provision for taping or otherwise delineating all four sides of the area to be sampled on window sills (such as a template), not only the two short sides.

The use of a pre-measured template prevented this error in the floor sampling procedure, but exposed a different issue for home test kit design. A small subset of the untrained participants did not understand what the word “template” referred to, and so did not use the template at all or used it incorrectly. Terminology was also a problem in the windowsill sampling procedure. Some participants sampled the window well instead of the windowsill area. This is a significant error given that the difference between lead dust loading results for interior windowsill and window wells can be very large and because there are different standards for each surface. In the Evaluation of the HUD Lead Hazard

Control Grant Program, the average pre-intervention dust lead loading levels for window sills was 340 $\mu g/ft^2$ and the average for window wells was 6073 $\mu g/ft^2$.[8]

The analysis of the demographics of the untrained participants provided insight into the variability of the untrained participant results. Education was a significant predictor of score. Participants who had a Master's or Bachelor's degree or had some college courses scored significantly higher than those with a high school degree or fewer years of school. This may explain in part the wide range of scores for the untrained group in comparison to the trained group. Those participants who had some prior experience with lead dust testing, including having their homes tested for lead dust, or observing or implementing a lead dust test, also scored significantly higher.

Based on the experiences and results of the untrained participants, several changes to the lead dust test kit used here could be made. More emphasis should be placed on illustration and less on descriptive text. The relationship between score and education level may reflect differences in literacy levels. The subset of untrained participants who were less successful in their performance may have benefited from instructions that included clearer images and definitions of the components and sample areas. Clear pictures of the steps in the procedure, or possibly a video, could overcome this obstacle. Templates should be included, but should be marked clearly as a template, and the different window parts, windowsill and window well, should be illustrated.

Renovation and remodeling activities, even when the work is not extensive, can produce significant amounts of settled lead dust in the home. Deferred maintenance can also cause high dust lead levels. The capabilities of different individuals for using a home dust lead test kit will always vary, and there is likely to be some benefit in using trained individuals over untrained ones in producing accurate and precise results. Nevertheless, the study demonstrates that homeowners and property managers or owners can perform dust testing using dust test kits if the kits contain proper instructions and if personnel are diligent and careful in performing the testing.

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