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Lead-Based Paint Awareness, Work Practices, and Compliance During Residential Construction and Renovation

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Abstract **The U.S. Environmental Protection Agency recently implemented the Renovation, Repair and Painting (RRP) rule that applies to pre-1978 residences because of the potential presence of lead-based paint. Enforcement of this rule may be difficult and therefore it is crucial to understand the awareness and beliefs of contractors and the general public because these will likely be major determinants of exposures resulting from residential renovation work. The study described in this article utilized two mailed surveys: one directed to the general public and the other directed to contractors. The surveys were conducted in New Jersey and Virginia. Field observations were also recorded for work sites in New Jersey. Results indicated a high awareness among the general public about the hazards of lead, a low level of screening by children's doctors for lead exposure, frequent use of work practices that generate lots of dust, poor hygiene among contractors, and the potential for low compliance of contractors with the RRP rule. In particular, contractors who do not believe lead is a serious health hazard are expected to have the lowest compliance with the RRP rule. These findings serve as targets for effective public health interventions through education and outreach.**

Introduction

Exposure to lead is associated with adverse health effects among adults and children. Lead-based paint utilized on homes built prior to 1978 is currently the most common source of exposure among the general public in the U.S. According to a survey published by the Department of Housing and Urban Development in 2001, 24% of housing built between 1960 and 1977 contains lead-based paint, 69% of housing built between 1940 and 1959 contains lead-based paint, and 87% of housing built before 1940 contains lead-based paint (Clickner, Marker, Viet, Rogers, & Broene, 2001). They also found that housing in the Northeast and the Midwest had about twice the prevalence of lead-paint hazards compared with housing in the South and West (Clickner et al., 2001).

The abundance of paint with elevated levels of lead pigment makes contractors remodeling these homes as well as the residents at risk of exposure to lead-based paint. Construction activity can result in the disturbance of lead-based paint creating a significant amount of dust and debris that contributes to both contractor and resident exposure. Many researchers have shown that lead can be released during residential remodeling work, and it can result in exposures among the workers and dissemination of lead-containing dusts throughout the house (Kiefer & Morley, 1996; Sussell, Elliott, Wild, & Freund, 1992; Sussell & Piacitelli, 2001, 2005; Sussell, Piacitelli, Chaudhre, & Ashley, 2002). In addition, it has also been documented that exposures can occur beyond the workers and residents of homes being renovated. For example, the children of construction workers can be exposed through "take-home" exposures (Clickner et al., 2001; Ewers, Piacitelli, & Whelan, 1995; Scholz, Materna, Harrington, & Uratsu, 2002; Sussell, Gittleman, & Singal, 1997; Whelan et al., 1997).

The National Institute for Occupational Safety and Health (NIOSH) Adult Blood Lead Epidemiologic Surveillance (ABLES) program has ranked construction work as the third most common job classification with workers having elevated blood lead levels (Alarcon, Graydon, & Calvert, 2011). NIOSH-funded state ABLES surveillance programs have found construction workers to be at particular risk of having elevated blood lead levels as a result of exposure to lead-based paint. For example, in New Jersey the construction and renovation business represents a significant number of adult blood lead

TABLE **1**

Demographics of Contractor Survey Respondents and General Public Survey Respondents

Demographic	Contractor Survey (*n* = 24) (#)	General Public Survey (*n* = 49) (#)	
Age			
<30	2	>25	1
30–50	5	25–35	5
>50	16	36–55	22
No response	1	>55	20
		No response	1
Primary language			
English	24	48	
Other	0	0	
No response	0	1	
Family income[a]			
Below average	2	10	
Average	13	17	
Above average	9	20	
No response	0	2	
Race			
African-American	5	9	
Caucasian	19	38	
Multiple	0	1	
No response	0	1	
Gender			
Female	2	28	
Male	22	20	
No response	0	1	
Location			
New Jersey	8	23	
Virginia	16	25	
No response	0	1	

[a]Relative to average median of $50,000/year.

cases reported to the New Jersey adult lead registry, with a total of 975 persons and 2,455 blood tests recorded from 2001 through 2006 alone (Blando & Lefkowitz, 2010). The New Jersey registry data show that the relative proportion of cases in the lead registry from the construction and renovation trades with significant blood lead levels (>25 µg/dL) appears to be increasing over time in New Jersey, with a 12% increase since 2001 (Blando & Lefkowitz, 2010). This is most likely the result of the recent decrease in manufacturing and the increasing need to renovate older homes with lead paint and the subsequent exposure among this cohort of workers.

As a result of the risk from exposure to lead due to construction activity, the U.S. Environmental Protection Agency (U.S. EPA) recently promulgated the Renovation, Repair and Painting (RRP) rule that applies to all residential structures built before 1978 with few exceptions (Renovation, Repair and Painting Rule, 2011). This rule includes provisions for education and training, work practices, workplace controls, and awareness as an intervention strategy to reduce the hazard posed by lead-based paint in the residential setting. Materna and co-authors (2002) showed that the educational intervention painters received to reduce lead exposure was moderately effective even one year after follow-up. Harrington and co-authors (2004) found some concerns about sustaining interest and compliance over the long term if incentives were not adequate to sustain compliance. Compliance with safe methods was much higher for work practices that were practical and not cost prohibitive (Harrington et al., 2004; Materna et al., 2002). Enforcement of the U.S. EPA RRP rule will be difficult, however, because of the very large number of jobs and the relatively small number of inspectors available to oversee work. Therefore, it becomes crucial to understand the motivation and incentives that would enhance compliance with this new regulation in the absence of strong enforcement capacity.

Many social, personal, psychological, cultural, economic, organizational, language, and job-related characteristics contribute to unsafe behaviors (Bust, Gibb, & Pink, 2008; Fung, Tam, Tung, & Man, 2005; Menzel & Gutierrez, 2010; Mohamed, Ali, & Tam, 2009; Robertson, Kerr, Garcia, & Halterman, 2007; Törner & Pousette, 2009; Village & Ostry, 2010). The health promotion and behavior-based safety literature demonstrates that personal beliefs and attitudes about health hazards and the seriousness of consequences can impact the action a person will or will not take to protect themselves. For example, Neitzel and co-authors (2008) showed that a training program developed and delivered around worker beliefs, knowledge, and use factors resulted in an effective educational intervention that nearly doubled hearing protection device use among construction workers. Lingard (2002) showed that first-aid training increased awareness among construction workers and this resulted in less tolerance for risk-taking behavior in work tasks when practical means were available to avoid risk. Behavior did not change at the work site for tasks where the worker perceived that behavior changes were not practical. Village and Ostry (2010) showed that workers who believed that interventions would be effective were more likely to take action in trying to reduce their rate of musculoskeletal injury. Arezes and Miguel (2006) found that the use of hearing protection was most effectively promoted when the workers believed the use of protectors would be effective in providing protection. The effect of the workers' belief was a stronger predictor of hearing protector use than a mandatory

or regulatory requirement to use the devices. They also found that workers were not very good at objectively judging their risk of hearing loss but rather based their use of hearing protection on faulty perceptions and beliefs about their risk. Interventions must address the target audience's beliefs and attitudes to motivate them to take action.

Our study aimed to further understand the awareness, attitudes, and beliefs about lead hazards among residential contractors and the general public. Contractors and the public were assessed through the use of a mailed written survey. In addition to the survey, contractors were also assessed through direct field observation of work performed during residential construction jobs.

Methods

Our study utilized two survey methods to collect data; the first was the use of two written surveys administered through the U.S. mail and the second method was direct observation of contractors conducting work on residential properties. The written surveys collected information about contractor and resident attitudes and beliefs about lead paint exposures and its associated health hazards. Our study investigated two hypotheses: 1) that contractor beliefs and attitudes would impact their behaviors and compliance with the new U.S. EPA regulations, and 2) that resident beliefs and attitudes would impact their awareness of lead hazards and U.S. EPA's regulations. A total of 1,000 written surveys were mailed to prospective survey respondents. The field observations involved contractors conducting work on residential properties and included an assessment of the work being performed and the methods being used on the job site.

Written Survey

Two separate written surveys were designed for our study. One was designed specifically for construction contractors and the other was designed specifically for residents who lived in properties at risk of containing lead-based paint. Both surveys were validated for face and content validity using standard methods and included both expert panel review and pilot testing. The contractor survey focused on their beliefs and attitudes about the new U.S. EPA rule, work practices, and their beliefs and experiences with the health hazards of lead. The survey questions about the U.S. EPA rule assessed the likelihood of compliance; questions about work practices assessed factors that have been associated with increased risk of exposure; and questions about the health hazards of lead assessed attitudes and beliefs about lead-based paint.

The survey of residents was primarily focused on awareness of the potential lead paint hazard in their home. Questions involved their awareness of factors that are associated with their risk of exposure to lead paint, questions about children living in the home, and questions about their awareness of the new U.S. EPA rule. In addition, the general public survey also asked residents, "Has your child's doctor ever asked you questions about lead paint or tested children living with you for lead poisoning?" Demographic questions were asked on both surveys.

Each group of survey recipients was identified by separate methods. Construction contractors were identified through the use of the Selectory Database (Dun & Bradstreet, Short Hills, New Jersey). This database contained every registered business and was categorized by Standardized Industrial Classification (SIC) codes. The database was searched for businesses registered with an SIC code of 1521 (general contractors–single family homes), 1522 (general contractors–other residential), 1721 (painters), 1751 (carpentry), and 1799 (special trade contractors–not otherwise classified). This search was limited to Mercer County, New Jersey, and Hampton Roads, Virginia. The purpose of this geographic limitation was that both of these areas were similar in their population demographics and the age distribution of their homes, but New Jersey has a NIOSH-funded ABLES program and Virginia does not have an ABLES program. These two areas are also similar to many other urban areas of the country that have older housing stock. A total of 863 companies were identified in Mercer County New Jersey, and 2,022 companies were identified in Hampton Roads, Virginia. A total of 250 companies in New Jersey and 250 companies in Virginia were randomly selected to receive a survey from those identified with the database.

Members of the general public who were sent the resident survey were identified through the use of public records and state

TABLE **2**

Odds Ratios Derived From Multiple Logistic Regression Model[a]

Explanatory Variable	Odds Ratio Point Estimate	Odds Ratio Confidence Interval	*p*-Value
Familiar with U.S. EPA RRP[b] rule	1.30	0.09–19.55	.85
Rule will protect people	11.97	0.96–149.31	.05
Lead exposure bad for your health	23.90	1.37–417.15	.02

[a]Where explanatory variables predict the outcome that the contractor believes respirators and Tyvek suits are practical.
[b]U.S. Environmental Protection Agency Renovation, Repair and Painting Rule.

TABLE **3**

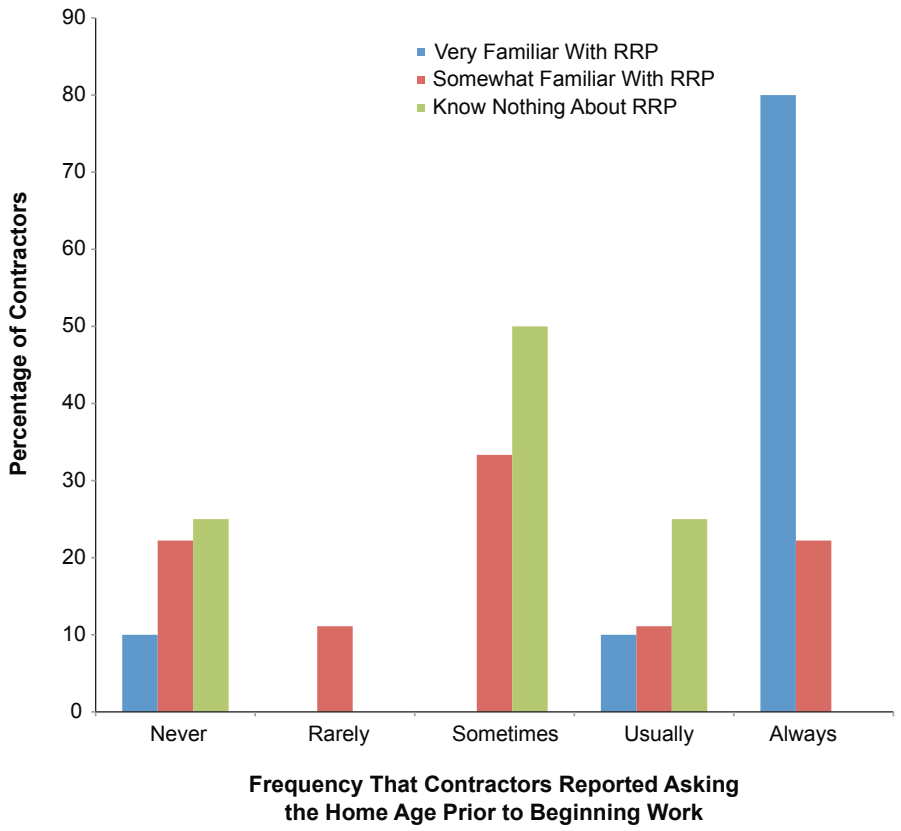
Odds Ratios Derived From Multiple Logistic Regression Model[a]

Explanatory Variable	Odds Ratio Point Estimate	Odds Ratio Confidence Interval	*p*-Value
Familiar with U.S. EPA RRP[b] rule	2.16	0.16–29	.56
Rule will protect people	0.760	0.087–6.63	.80
Lead exposure bad for your health	17.48	1.84–165.85	.01

[a]Where explanatory variables predict the outcome that the contractor believes disposable drop clothes are practical.
[b]U.S. Environmental Protection Agency Renovation, Repair and Painting Rule.

FIGURE **1**

Percentage of Contractors Who Ask the Age of the Home Prior to Beginning Work Stratified by Familiarity With Renovation, Repair and Painting Rule (RRP)



health department data on childhood lead poisoning incidence. Resident surveys were limited to zip codes within Mercer County, New Jersey, and Hampton Roads, Virginia, which had been identified by their respective state health departments as high-risk areas for childhood lead poisoning. Residential addresses were identified through the use of online white pages, community maps, and elementary school locations within the high-risk zip codes. Residences within approximately one mile of an elementary school located within a high-risk zip code were eligible to receive a survey. This included both property owners and renters. A total of 851 and 853 residences were identified in New Jersey and Virginia, respectively. Of these identified residential addresses, 250 residents in each state were randomly selected to receive the resident survey.

Frequency distributions of responses by survey question were used to describe the data collected on both the contractor and resident surveys. Cross tabs and Fisher's exact tests were used to assess these distributions with SAS v. 9.2. Logistic regression was used to assess the impact of contractor awareness and beliefs on the contractors' perceptions about specific controls required by U.S. EPA's RRP rule. This assessment included whether contractors were familiar with U.S. EPA's RRP rule, their beliefs about whether the rule will protect people, and their beliefs about the adverse health effects of lead exposure. The outcomes assessed included whether contractors thought the specific requirement in the U.S. EPA RRP rule to use disposable drop clothes and the requirement to use personal protective equipment were practical.

Field Observations

Our study also utilized observation of contractors working on residential job sites to supplement the data collected through the mailed survey.

Study Population and Recruitment

Field observations were conducted in New Jersey. Contractors were identified through several methods that included the ABLES blood lead registry in New Jersey, the Selectory Database, notification by homeowners requesting observation, and the New Jersey licensed lead abatement contractor list. The SIC codes 1721 and 1799 used for the database search of New Jersey contractors to recruit for field observations were limited to residential painting contractors and lead paint removal companies and included 257 companies. The ABLES database contained 52 individual companies, one company referred by a homeowner requesting observation, and the New Jersey licensed lead paint abatement contactor listing of 27 individual companies. Therefore, a total of 337 companies were contacted for a site visit.

Job Site Observations

Site visits utilized a standardized checklist that covered categories such as observed work practices, personal protective equipment, tools, and observations about site cleanup. Video exposure monitoring was conducted by filming work and synchronizing the video footage with a real-time TSI SidePak aerosol monitor. A cyclone was also used (flow rate of 1.7 liters per minute), which allowed us to measure the respirable dust fraction. This technique served as a visual tool to demonstrate and allow workers to "see" their exposures on film. Paint chip samples were also collected to help characterize the lead content of paints encountered during these site observations. U.S. EPA method 200.9, Revision 2.2 was used for the analysis of paint samples.

All of the information collected through the mailed survey and during the site visits was used to better understand factors that impact intervention effectiveness among construction workers.

Results and Discussion

The response rate for the mailed general public resident survey was roughly 10%, with 49 surveys returned out of 500 sent. The

response rate for contractors returning the mailed survey was approximately 5%, with 24 surveys returned out of 500 sent. The response rate for contractors participating in site visits was approximately 2%, with only six contractors participating out of 337 contacted. These relatively low response rates and small sample size limited the statistical power of the quantitative analyses presented below and the representativeness of the data must be interpreted carefully.

The demographic characteristics of the respondents for both surveys are listed in Table 1. It should be noted that all survey respondents spoke English as their primary language at home. Contractors were predominately male whereas the general public respondents had more female respondents. The general public survey respondents consisted of a population that was middle aged or older, predominately white, educated, and of average or above average income levels.

Residential Construction Workers Mailed Survey

The results of the mailed survey demonstrated that personal beliefs impacted contractors' attitudes. The mailed survey found that contractor beliefs about lead exposure and the effectiveness of the U.S. EPA RRP standard impacted their opinions and likelihood of compliance with the U.S. EPA standard. The multiple logistic regression model demonstrated that a contractor who believed "lead exposure was definitely bad for your health" compared to contractors who had doubts were 23 times more likely to say using a respirator and Tyvek was practical ($p = .03$) and 17 times more likely to say using plastic disposable drop clothes was practical ($p = .01$) (Tables 2 and 3). In addition, contractors who believed that "the RRP would protect people" compared to contractors with doubts were 12 times more likely to say that using a respirator and Tyvek was practical ($p = .05$) (Table 2). Contractors who believed that personal protection was not practical were less likely to utilize safe practices.

The survey also revealed that residential construction contractors who were familiar with U.S. EPA's RRP rule were more likely to ask the age of a home prior to beginning work (Figure 1).

Awareness of the home's age prior to work is one of the key parameters that predicts the likelihood of lead-based paint being present at the work site. If a contractor does not ask the age of the home they are less likely to be able to accurately predict the presence of lead paint. In addition, only 42% of contractors actually tested or got test results of the paint in the home prior to working. Therefore, this lack of awareness regarding the lead content of the paint indicates that contractors are unlikely to be able to accurately predict their risk of lead exposure. During our field observations for example, a contrac-

TABLE **4**

Common Tasks and Work Practices Observed During Site Visits (*N* = 8)[a]

Work Practice	Work Sites That Used Practice (#)	Work Sites That Used Practice (%)	Note
Dry scraping	6	75	
Wet scraping	4	50	
Manual sanding	6	75	
Power sanding	5	63	
Heat gun	2	25	
Paint remover chemicals	0	0	
Drilling or cutting	4	50	
Power/pressure washing	3	38	
Application of fresh new layers of paint	7	88	
Check for presence of lead paint	2	25	Only the lead abatement contractors checked by asking local health department. No general contractors checked.

[a]This included six general contractors and two site visits to a lead abatement contractor. These site visits were conducted prior to April 2010, when the U.S. Environmental Protection Agency's Renovation, Repair and Painting rule became effective.

TABLE **5**

Hygiene Habits Observed During Site Visits

Poor Hygiene Habit	Worksites With Poor Hygiene Habit (#)	Worksites With Poor Hygiene Habit (%)	Note
Did NOT wash hands before eating, drinking, smoking	4	50	We observed that general contractors did not wash, but lead abatement workers did.
Ate/drank/smoked in the work area	3	38	
Washed work clothes at home	5	63	
Wore shoes home	6	75	
Dry swept dust	3	38	
Used Shop-Vac without HEPA[a] filter	5	63	
Reused and shook out drop clothes	5	63	

[a]High-efficiency particulate air.

TABLE **6**

Survey Respondents Who Were Able to Answer Correctly Survey Questions About Lead Risk by Home Age and on Renter's Rights

Survey Question	High School Graduate Correct Answer % (#)	College Education Correct Answer % (#)	Fisher's Exact *p*-Value	Below Average Income Correct Answer % (#)	Average Income Correct Answer % (#)	Fisher's Exact *p*-Value
Type of home most likely to contain lead paint	84 (16)	90 (26)	.36	70 (7)	88 (15)	.24
Renters can insist landlord use lead safe practices	47 (9)	55 (16)	.65	70 (7)	47 (8)	.84

tor indicated that he could tell if lead paint was present simply by "looking at the paint." This is unlikely to be an accurate method for determining the likelihood of paint containing lead pigment, especially if newer layers of paint are present on top of older layers.

Residential Construction Worker Field Observations

The work tasks of lead abatement contractors were very similar to the work tasks performed by remodeling contractors. Among general contractors, specialty historic preservation contractors were unique, as they undoubtedly work with lead paint, often with very high lead content. We found that the paint samples we collected on historic structures were often around 13% or higher lead pigment by weight. In addition, historic preservation contractors cannot alter a structure and cannot dispose of any pieces of a structure, as these pieces have to be restored. Restoring old pieces is difficult, requires considerable workmanship and effort, and can therefore result in very high exposures in the absence of proper workplace controls. In the field, general contractors did not respond to moral arguments about the need for careful work to prevent exposure. They responded to business needs and fear of lawsuits. It was also observed that contractors did not fully appreciate their exposures and how their work practices influence their exposures.

Eight site visits were conducted during our study: six with general remodeling contractors and two site visits with a lead abatement contractor. The population of contractors in the ABLES registry was distinct from the general contractor population because they had received some previous medical evaluation and as a result were much more educated about lead exposure and clearly understood that this issue impacts them personally. They also had interacted with public health professionals previously. Of the six contractors we observed, two contractors also had children in their home with elevated blood lead values.

Many common themes were observed in the field. A summary of the techniques and work practices used by the contractors that we observed are listed in Table 4.

As demonstrated in Table 4, the work performed by these contractors involved mechanical tasks that required very close contact with paint and the associated dust. The field observations found that no general contractor checked the paint for the presence of lead prior to conducting their work. This observation is markedly different from the 42% of contractors who self-reported they tested the paint prior to beginning work on the mailed written survey. In addition, the field observations noted a very high prevalence of work tasks that generate considerable amounts of dust and hence are associated with potentially high exposures, such as power sanding (63%). By contrast, the written mailed survey of the contractors indicated that 42% rarely perform these tasks and 21% indicated they never perform these more hazardous work tasks. The marked difference between the survey results and the field observations may suggest that the contractors' perception of their risk does not match the reality of their risk.

The common hygiene habits observed in the field are listed in Table 5. The field observations demonstrated that many poor hygiene habits were frequent among the contractors. Highly variable and quickly changing work sites contributed to poor hygiene habits. This demonstrates that contractors need to become more aware of practical and simple solutions to improve basic hygiene at work sites. A significant number of contractors (54%; n = 13) indicated on the mailed survey that contractor compliance with the new U.S. EPA RRP rule is unlikely. This finding and the results of the field observations presented in Table 5 demonstrated that considerable effort will be required to change the work habits of contractors to reduce exposure to lead-based paint.

General Public Mailed Survey

The survey of the general public revealed that greater than 95% (n = 48) of respondents were aware that exposure to lead-based paint is bad for their health and the awareness appeared to be relatively high among all educational and income strata, with no statistically significant differences among the groups (Table 6).

Particularly problematic was the lack of attention that the general public survey respondents reported regarding their health care provider asking them about potential lead exposure and conducting the required lead screening (Figure 2). The general public survey demonstrated that 32% of respondents have not been asked by their child's doctor the necessary questions to screen for potential lead exposure, and when respondents who do not have children in their home are removed from the analysis this percentage rises to 55%. This is of concern because the survey respondents in our sample were drawn from residences within zip codes identified as high risk for childhood lead poisoning.

Overall, 39% of respondents did not know if renters could insist on lead safe practices. This has significant implications for communities where renters are prevalent. Some difference existed in awareness about renter's rights by income level but this was not statistically significant (Table 6).

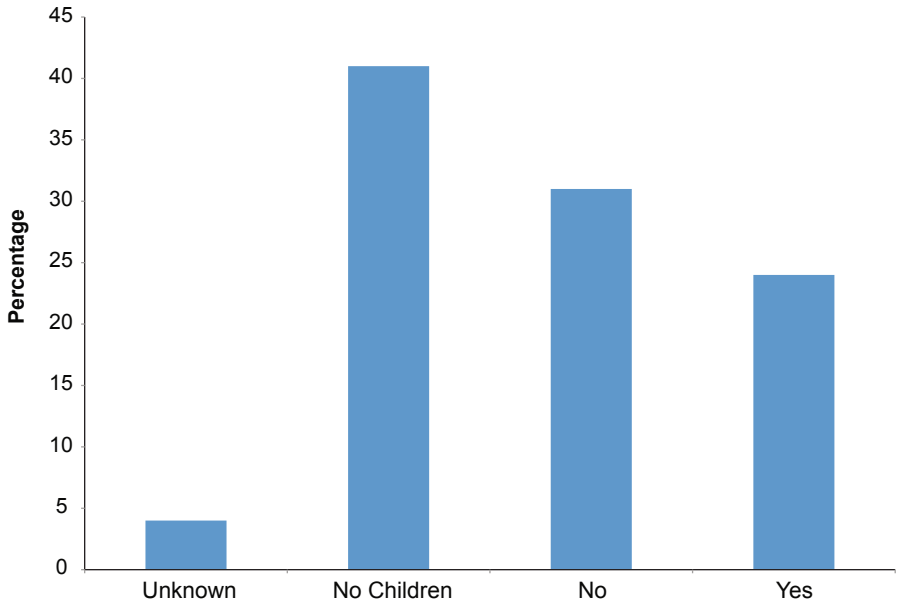
Conclusion

Our study demonstrated that residential remodeling contractors utilize techniques that generate dust and hence create a lead exposure hazard and that their perception of this hazard is not accurate. Contractors' beliefs about the seriousness of the health hazards of lead impact their perception about the practicality of prevention methods and this likely will reduce their compliance with the new U.S. EPA RRP standard requirements. Therefore, educational interventions need to target any doubt contactors have about the hazards of lead to their health.

The general public seems to be aware of lead-based paint hazards but their child's health care providers do not appear to be conducting the required risk assessments for lead exposure. This has serious implications for gaps in lead screening among children in communities at high risk of lead poisoning. In addition, residents who rent their properties must be made aware of U.S. EPA's RRP rule and understand that compliance is required in most rental properties.

FIGURE **2**

General Public Survey Responses: Has Your Child's Doctor Ever Asked About Lead or Tested Your Child for Lead Poisoning?



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