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Development and evaluation of two educational sessions on take-home lead exposure prevention for construction workers and their families

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Abstract

Take-home exposures occur when workers accidentally bring workplace contaminants home. Regular job responsibilities may expose construction workers to lead, which extends to their households via the take-home pathway. The present study aimed to develop and evaluate 2 educational sessions addressing take-home lead exposure tailored to construction workers and their families. Educational materials on take-home lead exposure and prevention strategies were designed following guidance from US government institutions and experts on construction work, lead exposure, and educational interventions. The educational materials were pilot-tested with construction workers and their family members during in-person or online sessions in English or Spanish. Changes in knowledge of take-home lead exposure were assessed through pre- and post-testing and open-ended feedback was collected from both participants and session facilitators. The study sample comprised 44 participants, including 33 workers and 11 family members. Among all participants, 81% were male, 46% were Hispanic or Latino, and the average age was 29 years. Post-test scores (μ = 93%, SD = 10%) were higher than pre-test scores (μ = 82%, SD = 19%), and younger participants (<30 years) were more likely to have a lower pre-test score compared to older participants (≥30 years). Overall, feedback from participants and facilitators was positive, indicating appropriate duration, appealing visuals, and ease of engagement through the training activities. Effective public health education for lead-exposed construction workers and their families is needed to reduce lead exposure disparities, especially among children of workers. Interventions must recognize that take-home exposures are not isolated to occupational or home environments.

Key words: construction; education; family; lead; prevention; take-home exposure; worker.

What's Important About This Paper?

Workers can bring workplace hazards, such as lead, to their homes, exposing their family members. This study describes a novel intervention to prevent avoidable take-home exposures to lead among construction workers and their families. The intervention provides education and increases dialogue and awareness among the most affected individuals about this oft-neglected exposure route.

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Introduction

Childhood lead exposure can adversely impact pediatric neurocognitive development and remains a significant public health challenge (Abadin *et al.*, 2007). While widespread efforts have reduced this burden in the United States (Dignam et al. 2019), no safe level of lead exposure has been identified. Children in low-income, older housing and those with lead-exposed parents are disproportionately exposed to lead (Levin et al. 2008; Chandran and Cataldo 2010; Leech et al. 2016; Hauptman et al. 2021). Specifically, children of construction and electronic recycling workers experience a greater risk of lead exposure and poisoning (Piacitelli et al. 1997; Whelan et al. 1997; Roscoe et al. 1999; Centers for Disease Control and Prevention (CDC) 2012Newman et al. 2015).

In adults, approximately 95% of BLLs above 25 µg/dL are work-related (Dignam et al. 2019). Construction workers, of which there are over 7.5 million in the United States (Bureau of Labor Statistics 2023), are among the most exposed occupational groups (Levin and Goldberg 2000; Alarcon 2016; Armatas et al. 2022). Job responsibilities such as demolition and paint removal expose construction workers to lead dust (Goldberg et al. 1997; Tak et al. 2008; Virji et al. 2008), which can subsequently impact children and other family members when tracked home from the workplace. Termed the take-home pathway (Piacitelli et al. 1997), this process inadvertently exposes family and household members to occupational contaminants. Take-home exposures among construction workers have been documented for both lead and other metals (Piacitelli et al. 1997; Ceballos et al. 2021, 2022).

While lead brought home from construction work can influence residential exposure, employer obligations to address take-home exposures are limited under Occupational Safety and Health Administration (OSHA) standard 1926.62 (Occupational Safety and Health Administration 1993). Briefly, the standard mandates training for workers exposed to lead at or above the action level (30 µg/m^3), but only requires stricter protections, including handwashing facilities, changing and storage areas, and additional personal protective equipment (PPE), for workers exposed to lead above the personal exposure limit (50 µg/m^3) (Occupational Safety and Health Administration 1993). Such provisions have been designed to reduce take-home exposures, but only take effect once workers have already been exposed. Few efforts have sought to exceed legal requirements in reducing workplace sources of lead or identifying lead-exposed workers for additional training to address and reduce take-home exposures proactively (Virji et al. 2008; Rodrigues et al. 2010). Furthermore, employers are not obligated to address post-shift conditions once employees leave the worksite nor to educate the families of their workers.

For both workers and communities, educational interventions serve as a common approach to prevent exposure to lead and other environmental contaminants. Previous research has evaluated the efficacy of educational interventions in reducing residential lead exposure (Lanphear et al. 1996, 1999; Jordan et al. 2003; Brown et al. 2006; Avila 2021). However, existing interventions have primarily addressed non-occupational sources of lead and their effectiveness in reducing exposure is inconsistent (Nussbaumer-Streit et al. 2020). Few interventions have targeted the take-home pathway, with existing studies focused on pesticides in agricultural settings (Liebman et al. 2007; Thompson et al. 2008; Arcury et al. 2009; Bradman et al. 2009; Salvatore et al. 2009, 2015) or take-home contaminants generally (Ceballos et al. 2020). To our knowledge, the California Department of Public Health (CDPH) has developed the only training targeting take-home lead exposure for construction workers and focuses on the workplace (California Department of Public Health 2002). Thus, despite evidence that construction workers and their families are exposed to lead through the take-home pathway, the efficacy of targeted educational interventions, for both workers and their families, has not been evaluated.

To address this gap, we sought to develop an educational intervention on both workplace and household strategies to comprehensively prevent take-home lead exposure. Specifically, we aimed to assess knowledge of take-home lead gained by workers and their families by participating in a tailored educational session and to determine the feasibility of administering the educational sessions for future studies through participant and facilitator feedback.

Methods

Study design

Study activities included developing, pilot testing, and evaluating 2 educational sessions. We developed the educational sessions in 2020 and conducted pilot testing from April to November 2021 for 2 target audiences (construction workers and their families), in 3 different formats (i.e. in-person individual, in-person group, and online), and 3 languages (i.e. English, Spanish, and Portuguese) (see Supplementary Fig. S1). We recruited in-person participants in Boston, Massachusetts, and online participants in the United States. We collected quantitative data, via pre- and post-session test scores, and qualitative feedback from participants and facilitators.

Development of the educational sessions

To train participants on take-home lead exposure, we developed the construction worker and family take-home lead exposure prevention educational sessions (the "worker session" and "family session"), targeting workplace and household barriers to exposure prevention, respectively. We based the content for each session on institutional guidance from the CDC (Centers for Disease Control and Prevention 2024), OSHA (Occupational Safety and Health Administration 2004), the Environmental Protection Agency, and Department of Housing and Urban Development (United States Environmental Protection Agency et al. 2021), and peer-reviewed literature.

We collaborated with 2 community partners, the Massachusetts Coalition for Occupational Safety and Health (MassCOSH) and New England Laborer's Health and Safety Fund (NELHSF). Each organization has a rich history and active initiatives for promoting workers' health and well-being through training and sustained community engagement. Project advisors, including experts on construction work, lead exposure, and education, provided feedback during regular progress meetings. Over multiple iterations of the educational materials, we requested comments on their content, scope, visual appearance, accessibility, and other potential improvements. We contracted a graphic designer to make the materials visually appealing and increase accessibility for participants with low literacy levels.

Worker session:

We adapted the worker session from a 1-h training on take-home contaminants and prevention techniques for workers (Ceballos et al. 2020). Through plain language, supporting graphics, and interactive activities, we sought to create opportunities for workers to reflect on their situation to identify behavioral risk factors for take-home lead exposure and possible solutions. We integrated the educational materials into a single training guide (see Supplementary Materials), which included information on lead in construction, a take-home exposure prevention graphic, and an action plan activity. By the end of their session, we encouraged each participant to prioritize at least one exposure prevention strategy following the Ottawa Personal Decision Guide, a resource for making health-related or social decisions (Patient Decision Aids Research Group 2012). In the present study, a trained facilitator administered each session, but the guide was created to have instructions clear enough for standalone use by participants should they revisit the content or share it with peers.

Family session:

The family session was designed to include both workers and their families or household members, similar to a previously published home-based intervention aimed at reducing take-home pesticide exposures among farmworker families (Salvatore et al. 2015). The family session sought to engage participants in an interactive discussion through motivational interviewing techniques (Miller and Rollnick 2012), which have previously been used for public health issues including substance abuse and intimate partner violence (McMurran 2009; Soleymani et al. 2018). The materials accompanying the family session were combined into a single guide (see Supplementary Materials), that included background information on lead, a handout on take-home exposure prevention behaviors, a self-scoring activity, and a family action plan with a calendar to track progress. By the end of the session, participants identified at least one strategy to prevent take-home lead exposure.

Pilot testing

After numerous revisions, we tested the sessions with workers and their families. Fig. 1 outlines the training plan followed for each session with further details in the Supplemental Material. Sessions lasted 30 to 45 min on average with six 5 to 10-min segments.

Recruitment

Participants were recruited via outreach through the MassCOSH and NELHSF networks. Eligible adult participants, fluent in English or Spanish, chose to participate either in person in the Greater Boston area or online via Zoom. Worker session participants were identified based on their previous or current occupation in construction (e.g. renovation, demolition, metalwork, etc.). Family session participants were eligible if they previously or currently lived with a construction worker. Each participant provided verbal consent after reviewing the informed consent form in their preferred language (English or Spanish), and all study protocols were approved by the Boston Medical Center and Boston University Medical Campus Institutional Review Board.

Administration of the educational sessions

In person versus online training:

Due to the COVID-19 pandemic, we converted the worker session into an online module, using Articulate 360, to make the training accessible to participants who could not attend a session in person, and to provide more flexibility for pandemic-related restrictions. We offered the family session in-person or online via Zoom using screen-sharing to present the materials. Once pandemic restrictions were lifted, we administered the family session in-person to those who agreed to a home visit, which allowed participants to show their living conditions to the facilitator directly to inform specific exposure prevention strategies.

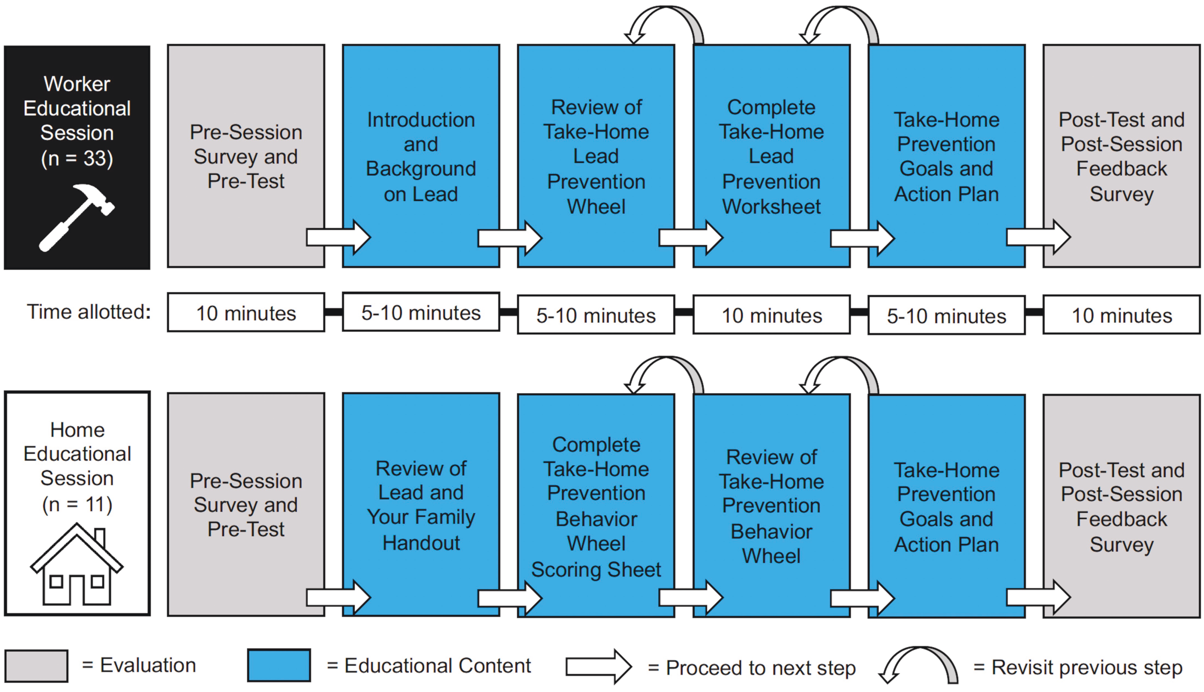

Fig. 1. Overview of pilot testing training plan for the worker and family educational sessions.

Individual vs. group worker training:

We designed the worker session to be administered to groups of workers at union training centers, focused on shared experiences of workplace barriers to change. We conducted 2 in-person sessions at union training centers with 7 and 15 workers, respectively. However, 11 workers received individual sessions due to pandemic restrictions.

Training languages:

To increase the accessibility of the sessions, we translated all materials into Spanish. Bilingual members of the research team were trained to administer the sessions in both English and Spanish. One worker session was delivered in English and interpreted into Portuguese, the participant's preferred language, to ensure full understanding.

Data collection and evaluation

Data were collected from participants immediately before and after the completion of the educational session using administered Qualtrics surveys. Following guidance from the National Institute of Occupational Safety and Health (Cohen and Colligan 1998), we assessed knowledge of take-home lead exposure and prevention behaviors using pre- and post-session testing, comprised of 10 yes/no questions specific to the worker or family session. Participants also provided demographic information including age, sex, race, ethnicity, education, and income level. Finally, we collected feedback from participants to assess their satisfaction with the session and materials. The research team met after each session to discuss perceived successes and challenges.

Statistical analysis

All data were summarized through descriptive statistics. Paired *t*-tests were conducted to evaluate differences between pre- and post-session test scores among the overall sample and stratified by session (worker or family). We employed Fisher's exact test to assess differences in demographic characteristics between participants scoring 70% or lower on their pre-test and those scoring higher. Finally, we sought to identify potentially "problematic" or misleading questions based on a high percentage of incorrect post-test responses, participants changing correct pre-test responses to incorrect post-test responses or participant feedback. All analyses were performed using Microsoft Excel (version 16.43), and R Studio (version 1.3.1093) software.

Results

Participant population and baseline knowledge

Our study included 44 participants, with 33 (75%) workers and 11 (25%) family members. Table 1

Table 1. Participant demographic characteristics by educational session.

	Total	Family session	Worker session
Sample size—*n* (%)	44	11 (25)	33 (75)
Age—mean (SD)	30 (11)	35 (13)	28 (9)
Sex—*n* (%)			
Male	35 (81)	3 (27)	32 (100)
Female	8 (19)	8 (73)	–
Ethnicity—*n* (%)			
Hispanic or Latinx	20 (46)	8 (73)	13 (41)
Not Hispanic or Latinx	23 (54)	3 (27)	19 (59)
Race—*n* (%)			
White	21 (60)	4 (44)	17 (65)
Non-White[a]	14 (40)	5 (56)	9 (35)
Household income—*n* (%)			
Up to $34 999	13 (36)	4 (40)	9 (35)
$35 000–$74 999	11(31)	1 (10)	10 (38)
$75 000 or more	12 (33)	5 (50)	7 (27)
Education—*n* (%)			
High school diploma or less	23 (53)	5 (46)	17 (55)
Some college	11 (26)	2 (18)	9 (29)
Bachelor's degree or greater	9 (21)	4 (36)	5 (16)
Marital status—*n* (%)			
Never married or separated	26 (69)	4 (57)	22 (71)
Married	7 (18)	3 (43)	4 (13)
Member of an unmarried couple	5 (13)	-	5 (16)
Session delivery—*n* (%)			
In person	29 (66)	4 (36)	25 (76)
Online	15 (34)	7 (64)	8 (24)
Training language—*n* (%)			
English[b]	34 (77)	5 (45)	29 (88)
Spanish	10 (23)	6 (55)	4 (12)

Notes: One participant missed the pre-session survey completely and did not report their gender, age, ethnicity, or level of education; 9 participants did not report a race, 8 participants did not report income level, and 6 participants did not report marital status.
[a]Non-white race includes Black/African American, American Indian, and Other.
[b]One participant had their session delivered in English.

summarizes participants' demographic characteristics, stratified by session (home vs. worker session). All workers who reported their gender (97%) were male, while the majority of family session participants were female (73%). Participant ages ranged from 18 to 70 years; on average, family members (35 years, SD = 13) were older than workers (28 years, SD = 9). Among all participants, 50% had a high school diploma or equivalent, 57% reported never being married, and 75% had current or previous work experience in construction. Most participants completed in-person sessions (66%) in English (75%).

Differences in baseline knowledge were also observed by select characteristics (Supplementary Table S1). Mainly, younger participants (less than 30 years) were more likely to score 70% or lower on their pre-test compared to older participants (30 years or greater). We did not observe differences in baseline knowledge between workers and family members, by education level, or by training language.

Effectiveness of the educational sessions

All participants' knowledge of take-home exposure prevention behaviors increased by 11 percentage points after the educational sessions from 82% to 93% (Table 2). Our results suggest that knowledge gain was slightly greater among family session participants (13 percentage points, 85% to 98%) compared to workers

Table 2. Quantitative assessment results from the 2 take-home prevention educational sessions.

	Mean score[a] (SD)		Mean difference (95% CI)	*P*-value[b]	% change
	Pre-test	Post-test			
Total (n = 42)	82% (19)	93% (10)	10% (5, 16)	0.0005	13
Family session (n = 11)	85% (23)	98% (4)	13% (−3, 28)	0.09	15
Worker session (n = 31)	81% (18)	91% (11)	9% (4, 15)	0.002	12

[a]Pre- and post-assessments included 10 questions each. Reported test scores are on a scale from 0% to 100%.
[b]Differences between pre- and post-assessments were tested using paired t-tests.

(10 percentage points, 81% to 91%). Twelve participants (29%) scored 70% or less on the pre-assessment, but only 4 (10%) did following training. Review of individual questions revealed that baseline knowledge was lowest regarding the efficacy of showering after work and limiting family contact with work clothing or shoes in preventing take-home exposure (Supplementary Table S2). While the number of incorrect responses decreased overall from pre-to post-testing, select questions were flagged for improvement (Supplementary Table S2).

Participant and facilitator feedback

Overall, participant feedback revealed satisfaction with the educational sessions. Among workers, 88% felt their session facilitator was effective, 85% felt the instructions were clear, 79% felt the training was relevant to them, and 76% felt that the length of the training was excellent. Family members also provided positive feedback, with all participants (n = 11) reporting that educational materials and the trainer's answers to their questions were excellent, 91% that the session overall was excellent, and 73% that their family's participation was excellent. Most participants felt excellent (n = 31, 70%) or good (n = 11, 25%) about their ability to prevent take-home lead exposure. Open-ended feedback also revealed that participants appreciated that the recommended prevention strategies were easy to understand, practical, and flexible; in addition, they enjoyed the overall design and appearance of the educational materials.

Session facilitators also provided generally positive feedback. Each session lasted long enough to complete the developed activities without rushing. Both sessions were easily adapted to the needs and interests of different participants and readily opened dialogue on take-home lead exposure and prevention behaviors. While the educational materials for the worker session were originally combined into a single booklet, those for the family session were not, making them harder to use as individual worksheets. Thus, we combined the materials for the family session into a single guide (see Supplementary Materials). Interaction between the facilitators and participants throughout the session kept parties engaged, which was aided by simple visuals.

Discussion

We developed and evaluated 2 educational sessions for construction workers and their families to address take-home lead exposure and promote exposure prevention behaviors. Our findings suggest that well-designed educational interventions can successfully increase participant knowledge of take-home lead exposure. Additionally, we encouraged both workers and family members to prioritize exposure prevention goals, but more follow-up is needed to observe how knowledge gained translates to behavioral change. Importantly, pilot testing confirmed the feasibility of the trainings for both the target audience and facilitators, supporting expanded evaluation of this work in the future.

We first designed 2 educational sessions directed at construction workers and their families to address the lack of existing educational materials on take-home leads. While extremely comprehensive, the CDPH training utilizes technical language, lasts approximately 8 h, and has not been formally evaluated in existing literature. As such, it is appropriate for workplaces with established lead safety programs (California Department of Public Health 2002) but is not readily accessible to the workers' families or the broader community. Educational materials, such as those from federal and state health agencies, address many sources of lead but rarely connect occupational sources to the risk of exposure for workers' families. For example, the Philadelphia Lead Safe Homes Study created a handbook addressing lead-based paint hazards (Campbell et al. 2011). Similar programs in Connecticut (Buzzetti et al. 2005), Arkansas (Ferguson et al. 2011), and Mississippi (Mitra and Anderson-Lewis 2021) have trained contractors, painters, realtors, inspectors, and homebuyers on residential sources of lead, but none have emphasized the take-home pathway or targeted the families of lead-exposed workers. The scarcity of resources hinders the ability of workers' families to learn about take-home lead and subsequently prevent exposure.

Numerous factors affect the accessibility of educational materials including their readability, duration, appearance, interactivity, and delivery method. Following CDC guidance, many lead education materials are prepared at a 6 to 8th grade reading level (Okatch et al. 2021). However, populations at high exposure risk, including low-income African American and Hispanic families, are also more likely to have low literacy levels and may benefit from lower reading-level materials. Additionally, lead exposure interventions should be culturally relevant and available in multiple languages to successfully reach immigrant populations in the United States (Vallejos et al. 2006; Kreps and Sparks 2008), who are disproportionately represented in professions like construction (Vallejos et al. 2006). State health departments have published information to help increase awareness of take-home lead exposure (Dickman 2017), which could explain the baseline knowledge observed among our participants. However, there remain barriers to translating knowledge into prevention behaviors, especially for low-resource populations (Jordan et al. 2007; Kristen S. Montgomery and Kara Jone Schubart 2009). Employers can play a critical role in facilitating behavioral change by providing all workers, regardless of their lead exposure status, access to showers, changing and storage facilities, and other established resources to reduce take-home exposures. Still increasing knowledge of environmental exposures is foundational for promoting health-protective behavioral change (Gray 2018). Our developed educational materials specifically sought to elevate awareness of take-home lead among construction workers and their families, which is critical for reducing long-standing health disparities.

After developing the educational sessions, we assessed their effectiveness and feasibility. Many trainings have also been designed for workers with existing or technical knowledge (California Department of Public Health 2002; Buzzetti et al. 2005), which may not be the case for their families. We avoided jargon or technical terminology to support future use in community settings, such as local health departments, for populations with limited knowledge of take-home lead exposure. Knowledge gained in our study (10 percentage points) is comparable to select lead education studies (Buzzetti et al. 2005; Ferguson et al. 2011; Ceballos et al. 2020) but lower than others (Kersten et al. 2004; Campbell et al. 2011). Pre-test scores also indicated that participants 30 years or older had higher baseline knowledge of lead, consistent with the Chicago Lead Knowledge Test (CLKT) (Mehta and Binns 1998). This may be partially explained by more years of work experience, during which knowledge was informally acquired, among older workers. Still, existing knowledge assessments have limited focus on take-home lead exposure (Mehta and Binns 1998; Buzzetti et al. 2005). Determinants of take-home lead knowledge merit further investigation, especially with greater statistical power. Future iterations of this work plan to revisit the knowledge assessments and undergo additional testing to confirm their validity.

We also evaluated the structure and implementation of the educational sessions. Efforts to raise awareness of lead hazards have been attempted through diverse formats and platforms. In Connecticut and New York, media campaigns on lead poisoning prevention have shown success in reaching targeted communities and increasing parental knowledge (McLaughlin et al. 2004; Greene et al. 2015). Strategies included billboards, newspaper advertisements, signs on buses, sanitation trucks, trains, and more. Educational videos have also been used to promote the distribution of lead knowledge (Kersten et al. 2004; McLaughlin et al. 2004). Our educational sessions aimed to accommodate different learning styles through oral, visual, and written content. Additionally, motivational interviewing has proven effective in behavior change (McMurran 2009; Soleymani et al. 2018) but has not been previously used to address environmental exposures.

Finally, we captured participant and facilitator reactions to session implementation. Unlike other trainings, which can take several hours to complete (California Department of Public Health 2002; Buzzetti et al. 2005), our educational sessions can be completed in less than an hour, which is more reasonable for workers and their families based on participant feedback. Still, the sessions can be extended if participants remain engaged and seek to continue discussion about their situation. We also explored how training factors affected accessibility, including in-person versus online delivery, language, and visual appearance. As the COVID-19 pandemic disturbed the frequency and delivery methods of many in-person trainings (Sarpy et al. 2022), we offered both educational sessions remotely to allow for increased flexibility for participants. While many workers may still prefer in-person trainings (Sarpy et al. 2022), having an online option may support increased participation for those who prefer remote training in the future.

Limitations and next steps

As a pilot study, certain limitations are important to address. The COVID-19 pandemic introduced unexpected challenges for recruitment and study conduct. Many findings from the present study were constrained by the need to stratify a small number of participants. Increased sample size is necessary to better understand participant characteristics associated with knowledge of take-home lead exposure and prevention behaviors. Future testing should also aim to measure knowledge gained once more time has elapsed since the training was conducted. Study participants were predominantly based in the greater Boston area, but construction practices and lead education may vary geographically, especially outside the United States. The original study design intended all sessions originally, we did not aim to include remote participants, but we could offer both educational sessions virtually and fully convert the worker session into an online training. Testing these adaptations corroborated their feasibility and provided increased flexibility for future trainees. We did not test the finalized family session booklet or alternate verbiage of select assessment questions, 2 recommendations were received from this work. Lastly, we compensated participants for their time, but this may not be practical if local health departments or unions administer these trainings in the future. As this is the first instance where both workers and their families received tailored training to prevent take-home lead exposure, further work is vital to determine knowledge and behavior changes over time.

Conclusion

Tailored educational interventions to reduce take-home lead exposure are needed for construction workers and their families. Our findings demonstrate the feasibility and effectiveness of educational sessions to increase knowledge of take-home lead exposure among worker and family audiences, especially when flexible means of participation are offered. Successful interventions should avoid isolating take-home exposures as either occupational or household issues by engaging workers and their families collectively.

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Conflict of interest

The authors declare no conflict of interest.

Data availability

The data will be shared on reasonable request to the corresponding author. Complete versions of the training materials in (English/Spanish) are in the supplemental materials.

Supplementary material

Supplementary material is available at *Annals of Work Exposures and Health* online.

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