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A community-based intervention for low-income families to reduce children's blood lead levels between 3–9.9 μg/Dl

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ABSTRACT

Q17 **Introduction**: In 2012, the Center for Disease Control announced children's blood lead levels (BLLs) above 5 μg/dL should be provided assistance, as no level of lead exposure is safe.

Method: A community-based randomized controlled trial targeting children from low-income families (BLLs: 3–9.9 μg/dL) was implemented utilizing educational and environmental tactics.

Results: All groups evidenced a significant decrease in children's BLLs and a significant increase in lead knowledge but no main effects based on group assignment. When compared to a post-hoc passive control group, all intervention groups evidenced significant BLL reduction.

Discussion: Findings are discussed in terms of low-cost primary prevention initiatives and mechanisms explaining intervention efficacy.

Introduction

Consensus has existed for decades among lead exposure experts that any amount of exposure is detrimental to young children's health and development (Bellinger & Bellinger, 2006; Lanphear et al., 2005; Needleman, Schell, Bellinger, Leviton, & Allred, 1990). Consequently, the Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) recommended in January 2012 that the blood lead level (BLL) reference range be lowered from 10 to 5 μg/dL to improve prevention efforts (ACCLPP, 2012). Using terms like "threshold" and "lead poisoning" were discouraged, as this provided a false sense of safety to families with children who are exposed to lead at lower levels (Betts, 2012). Families whose children are not flagged within a "level of concern" but whose children still had evidence of exposure may feel that they do not need to actively try and reduce their children's lead exposure and that their children are not at risk for consequences due to their exposure. Policy changes passed in May of 2012 integrated these suggestions, but prior to these policy changes, an intervention was conducted targeting low-income families with children testing between 3–9.9 μg/dL. The following study

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presents results of this intervention with important implications for prevention efforts in light of the recent policy change.

Primary prevention tactics targeting household lead exposure have been integrated into public policy, in particular for families in poverty (Bernard, 2003). Lead exposure has been called a social injustice because children from families in poverty and ethnic minority groups have compounded risk and are disproportionately exposed to lead as compared to higher SES families and Caucasian children (Dilworth-Bart & Moore, 2006). Poverty is linked to fewer resources and poorer physical environments; it is directly related to such risk factors as substandard housing (i.e., housing age, lead-based paint condition, plumbing, lead contaminated soil) and parental employment in factory settings, and indirectly influenced by dietary intake and access to medical services. For example, federal mandates require that children on Medicaid and in Head Start programs receive lead tests at 12 and 24 months. Moreover, families should be provided basic information concerning lead risk and protective factors as a cost-effective primary prevention strategy (US EPA, 2008). These primary prevention efforts may not be enough for reducing children's exposure and preventing detrimental outcomes; research has demonstrated lead testing among Medicaid recipients is below par (ACCLPP, 2012; Polivka, Salsberry, Casavant, Chaudry, & Bush, 2006) and educational interventions or dissemination of brochures have shown mixed effects in helping families decrease their children's BLLs (Bernard, 2003; Campbell & Osterhoudt, 2000; Griffin & Dunwoody, 2000; Polivka, 1999). Therefore, existing primary prevention tactics alone may not be enough and more intensive lead reduction strategies may be necessary.

Environmental tactics to prevent exposure include lead dust removal in the home through cleaning and home risk assessments. Past research initiatives implementing cleaning strategies have incorporated costly and time-intensive initiatives like professional cleaning or cleaning efforts by a research staff to increase the frequency and/or quality of cleaning, to less costly and less intensive strategies such as providing families with inexpensive cleaning tools (i.e., bucket, mop, cleaning solution) and encouraging recommended cleaning habits (see studies presented in Yeoh, Wolfenden, Wheeler, Aplerstein, & Lanphear, 2009 and Ettinger et al., 2002; Rich et al., 2002; Tohn, Dixon, Wilson, Galke, & Clark, 2003). The effectiveness of these lead dust reduction strategies have varied in terms children's BLL and lead dust reduction, though the long-term impact of the cleaning interventions were either not examined or not supported. In contrast to cleaning, lead hazard control efforts through more costly home remediation efforts to reduce lead dust has provided evidence of long-term effectiveness (Wilson, Galke, Clark, & Bornschein, 2004). The combination of environmental interventions through home risk assessment and cleaning may prove to be more effective.

To test the effectiveness of these educational and environmental intervention tactics on a sample of children with levels of exposure below 10 μg/dL but with detectable BLLs above the national BLL average (3–9.9 μg/dL; Wheeler & Brown, 2013), the current study examined the impact of whether or not participants received a cleaning kit and/or risk assessment on child BLL reduction and parental lead exposure knowledge. Families were randomly assigned to receive (a) education on lead poisoning (i.e., active control group), (b) a cleaning kit, (c) a home risk assessment, or (d) both a cleaning kit and a home risk assessment. The greatest reduction in children's BLLs and increase in lead exposure knowledge was expected for participants receiving the combination of both the risk assessment and cleaning kit, and families receiving cleaning kit and risk assessments separately would benefit over the control group.

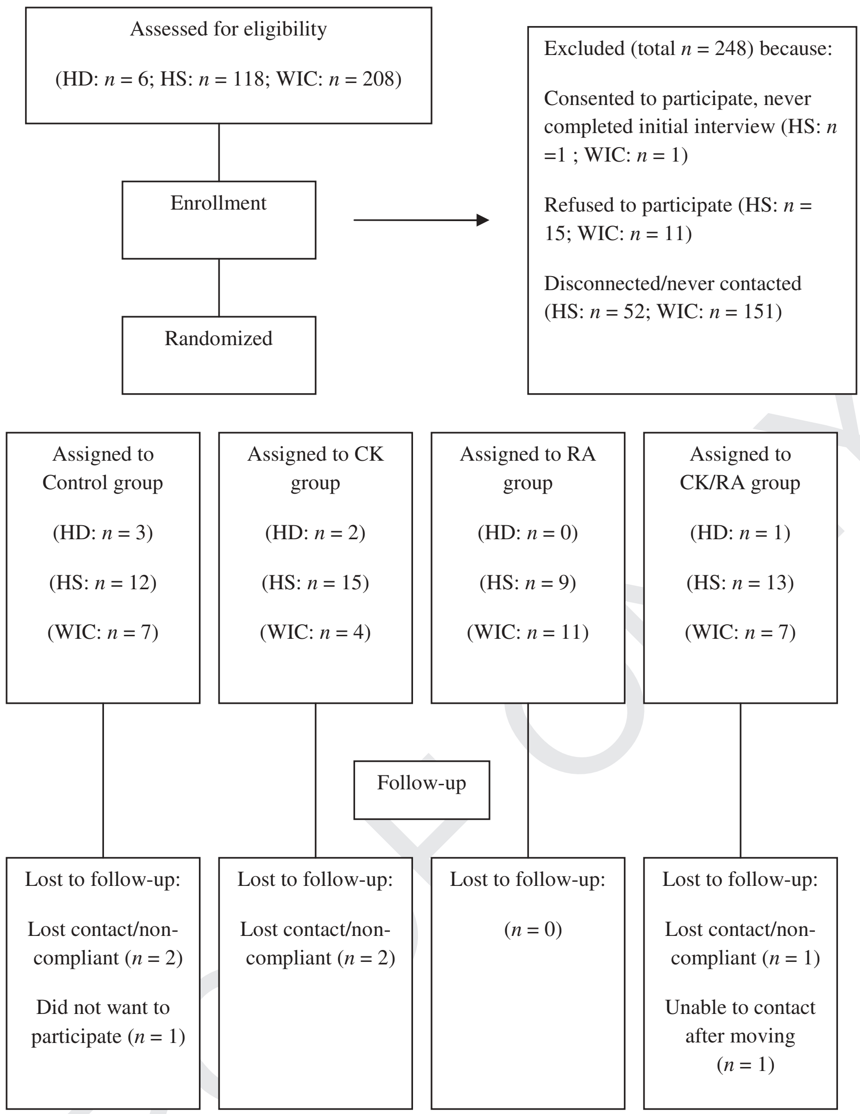
Method

Participants

Low-income families were recruited from a medium-sized midwestern city if their children were less than 6 years old and had a BLL between 3–9.9 μg/dL (see Figure 1). A total of 84 participants were recruited for the project from Women, Infants, and Children (WIC; n = 29), Head Start (n = 49), and the local Health Department (n = 6). The study was approved by the university institutional review board and informed consent was obtained from all participants in person at the initial interview. The average BLL in the sample recruited was 5.29 μg/dL (SD = 1.81; range = 3.0–9.3). Sealed envelopes contained the name of each of the four intervention groups, which were shuffled to ensure random order. Interviewers selected an envelope prior to conducting an initial interview; the envelope was opened at the end of the initial interview in front of the participants and then the associated intervention visit was scheduled. After participants were randomly assigned to the four intervention conditions, no difference was found between the conditions based on recruitment site, ethnic make-up, child or parent age, education level, or income (see Table 1). The sample consisted of Caucasian (32.1%), African American (28.6%), and Latino (39.3%) families.

Project design and procedures

There was a 14.7% attrition rate, but missing data due to attrition was deemed to be missing at random (MAR) and not a threat to internal or external validity as there was no significant differences between those retained in the study and those who dropped-out based on initial BLL, recruitment site, intervention group assignment, and demographic



Q14 **Figure 1.**

characteristics (Nicholson, Deboeck, & Howard, 2017). Once verbal agreement to participate was collected over the phone, an initial interview was scheduled at the family's home to obtain written consent and collect information on demographics and current lead exposure risk.

At the end of the initial visit, families were randomly assigned to one of the four groups. All groups received EPA pamphlets on risk factors related to lead exposure and steps to reduce the presence of lead in the home; the control group only received education through brochures. The intervention conditions received: a cleaning kit, including a Riccar Radiance HEPA vacuum and verbal and written instructions on how to properly clean to

Q18 **Table 1.** Participant demographic information.

Child variables	
Mean age (*n* = 84)	3.94 years (1.51); range 1.64–5.96
Parent variables	
Mothers' mean age (*n* = 74)	29.08 years (5.83); range 20.16–45.42
Foster/Adoptive/Grandmothers' mean age (*n* = 10)	43.70 years (7.88); range 32.97–54.34
Fathers' mean age (*n* = 3)	30.78 years (5.34); range 24.87–35.25
Education	
Less than HS	22.62%
Attended HS	22.62%
Completed HS/GED	28.57%
Some College/College degree	26.19%
Income	
< $700/month	27.16%
$701–$1,300/month	35.80%
$1,301–$2,200/month	20.99%
> $2,200/month	16.05%

Note. There were no significant differences between demographic characteristics and group assignment. Standard deviations presented in parentheses. Monthly income calculated through a combination of employment, Temporary Assistance for Needy Families (TANF), and child support. Three families could not report on their monthly income.

reduce lead; a professional home inspection for lead and consultation outlining specific risks present and steps to alleviate risks; or both the home risk assessment and the cleaning kit. These intervention conditions were implemented at the second visit within a few weeks. To maximize standardization of the intervention across the research team, training was provided that focused in-depth on program objectives and procedures and provided practice to develop confidence, self-efficacy, and proficiency in completing the intervention in a similar manner for each participant (Horner, Rew, & Torres, 2006).

The timeline of the intervention was 6 months between the initial and final interviews. During this time, families were called once a month to complete a brief phone interview to stay in contact with the families to reduce attrition and assess changes due to intervention efforts. Phone calls were scripted and specific questions were tailored to the different groups based on changes participants could be engaging in due to the program; all participants were asked about brochure utility and satisfaction. Phone calls had a high rate of completion (Month 1: 92.5%; Month 2: 82.1%; Month 3: 79.5%; Month 4: 79.4%; Month 5: 89.6%). After approximately 6 months, children were retested for lead through a capillary blood draw. Due to the fact that lead has a half-life of 30 days in the blood-stream, if the source of children's exposure had been reduced or eliminated as a result of the program, there would be a subsequent decrease in children's BLLs by the end of the study (Rabinowitz, Wetherill, & Kopple, 1976).

Families received monetary compensation for completing interviews which totaled $50. The intervention groups also received compensation in the form of the risk assessment (valued at approximately $500/assessment) and/or cleaning kit (valued at approximately $1,100); however, the value of these services was not disclosed to the families. During the project, vacuums were fixed at the expense of the project, which occurred for approximately one-third of the families and ranged in price from $20–120 per repair. Two mothers broke their vacuums twice during the 6 months they were involved in the project. Vacuum bags were provided throughout the duration of the project. Families were allowed to keep the vacuums after the study.

Intervention conditions

Active control: education through brochures

Active control groups engage participants in activities that could account for program effects related to participation by implementing the standard of care (Lindquist, Wyman, Talley, Findorff, & Gross, 2007). In the current study, the active control group received the EPA brochures during the intervention visit which were written around an eighth- or ninth-grade reading level. The implementation of a control group in this manner provides a more rigorous and ethical comparison group for determining intervention efficacy, and decreases the chance of type I errors (Borkowski, Smith, & Akai, 2007). For all participants, the topic of each brochure was introduced and, to standardize the instructions given to each family, only the main headings of the brochures were read to the families and then families were asked to read them more carefully on their own, and that they would be asked if they read the brochures at the first monthly phone call. The brochures presented preventative measures families could implement to reduce lead exposure: dietary habits (Environmental Protection Agency, 2001), cleaning practices to eliminate lead dust (Channing L. Bete Co., 1997), and habits families could implement to reduce lead dust, such as removing shoes when entering the house to eliminate tracking in dirt from the outside (Environmental Protection Agency, 2000, 2003).

Passive control group: health department tracking database

A passive control group, in contrast to an active control, receives no intervention services, so aspects of the study design could not account for BLL changes. To collect a passive control group, a chart review was conducted at the county health department using the CDC's statewide Systematic Tracking of Elevated Lead Levels & Remediation software application (STELLAR), which systematically tracks BLLs nationwide for children. Children were selected who were tested for lead during the same time period of the project, had BLLs within the study recruitment range at an initial test, and had a retest that was conducted at least 6 months after the initial test, resulting in the identification of 1,049 children. Due to HIPPA regulations, the only information that could be removed from the health department included lead levels, child age, gender, and dates of testing. Furthermore, a health department employee had to assist with finding this information for each child identified by the query, and no one associated with the project was allowed direct access to the database. Consequently, a random sample of children (n = 29) from the query was included due to the time-constraints imposed by the use of a health department employee in pulling the data from the query into a dataset (72.4% male; M = 2.10 years; SD = 1.53).

Cleaning kit

Families receiving a cleaning kit were given cleaning tools (e.g., Riccar Radiance HEPA vacuum, two buckets, Trisodium phosphate [TSP] detergent, gloves, shop towels, washrags) and a two-page instruction on proper ways to clean that elaborated on the cleaning brochures received by all groups (Channing L. Bete Co., 1997). Researchers read the entire two page instruction document in person, which encouraged families to implement specific cleaning strategies weekly, such as using a HEPA vacuum, a 2 bucket cleaning system, TSP cleaning solution to mop and dust, and wet-dusting instead of dry-dusting. Frequent and thorough cleaning was encouraged with a focus on cleaning where children spend most of their time and where lead dust often accumulates, such as window sills and door frames (Rich et al., 2002).

Home risk assessment

If families were assigned to receive a risk assessment, a professional company was scheduled to test the home for lead hazards using dust wipes and an X-ray Fluorescence (XRF) spectrometer. Dust wipes were collected by wiping areas of the floor and window ledges with wet-wipes, which were sent to a licensed lab for lead content. The XRF spectrometer gives an immediate reading of lead content on surfaces. A follow-up visit was scheduled to present the risk assessment report to the family and offer options for minimizing and/or removing risk present in the home. Families could choose which strategy to take, ranging from costly and time intensive to relatively low-cost and non-invasive. A copy of the report was left with the family, and if requested, a second copy was provided to give to their landlords. The reports were considered an aspect of the intervention so families could take remediation actions such as minimizing the time a child spends in rooms with high lead levels or adopting more stringent cleaning habits that concentrate on these problem areas. Home risk assessments have commonly been used as a measurement tool to assess the quality of the home environment but have been provided to participants as an aspect of the intervention less often (see Brown, McLaine, Dixon, & Simon, 2006).

Combination of cleaning kit and risk assessment

If a family was assigned to receive the cleaning kit and risk assessment, both were administered during the intervention visit. The researchers went over the cleaning instructions while the home risk assessment was conducted. A follow-up with the participant was either administered in person or over the phone to discuss the results of the risk assessment, and a copy of the assessment was provided.

Measures

Lead exposure risk: parental self-reports and home risk reports

Risk due to housing age was assessed through self-reports of housing age, and their home's precise age was retrieved from public records through an internet search; public records can provide an unbiased account of environmental risk like housing and neighborhood lead exposure risk (Nicholson & Cleeton, 2016). Lead exposure risk in the home was assessed by a self-report from the participants administered by a trained researcher during the initial interview, such as housing, hobbies, and employment. Self-reports of risk are inherently poor. To minimize risk due to participant bias and increase validity of self-reports for home risk, strategies were taken like listing out all hobbies and jobs that may put individuals in contact with lead. This approach is preferable to asking open-ended questions like, "Do you have a hobby or employment that exposes you to lead." (Nicholson & Cleeton, 2016)

Brochure effectiveness

Participants were asked at the first monthly phone call if they had read the brochures, if they made any changes because of them, and if they found the brochures helpful. If participants reported at the phone call they had not read the brochures, they were told they would be asked again at the next phone call. It was noted how many months it took them to read the brochures and if they never read them.

Cleaning and home repair

Parents were queried on the frequency of their cleaning for mopping, dusting, vacuuming, and cleaning toys and the types and costs of repairs they had made to their home at baseline, during each monthly phone call, and at the final visit. If receiving the cleaning kit, parents were asked specifically if they had changed their cleaning habit and how. Techniques the families adopted that were encouraged by the intervention were noted (i.e., using TSP cleaner, changing cleaning location).

Lead knowledge

Participants were asked 18 questions concerning factors which place children at risk for lead exposure (i.e., "Crystal, pottery, and ceramic dishes may contain lead") and how this can be prevented (i.e., "Boiling water removes lead"). Answers were sum-scored (range 0–18), with "I don't know" and incorrect answers given a score of 0 and correct answers given a score of 1. Higher scores indicated a greater awareness of lead risk and protective factors. Chronbach's alpha for the initial measure of lead knowledge was 0.67.

Blood lead levels

Children's initial BLLs were collected through records at WIC and Head Start, and referrals from the Health Department. WIC and health department samples were capillary draws (i.e., blood drawn from a finger prick) conducted on-site by trained professionals and sent to a private, licensed, and certified testing facility employing methodologies accepted by the CDC (Tamaracmedical.com). Capillary blood draws have been documented as highly correlated with venous samples (i.e., blood drawn directly from a vein) with a mean difference between capillary and venous draws being 1 µg/dL (Schlenker et al., 1994). Head Start collected blood lead information for students through their health care practitioners, such that the type of draw (i.e., venous or capillary) and the laboratory used for the blood analysis was unavailable. All samples, however, were taken by trained health care professionals, ensuring confidence in the samples' analyses. Final BLLs for the study were collected by the director of the WIC program and analyzed at Tamarac medical laboratory.

Results

(Table 2) presents the families' perceived risk for lead exposure by intervention group. Most families reported at least one risk. A small minority reported having lead risk at their place of employment, with almost a quarter of the sample reporting a hobby with the potential for lead exposure. The majority of families lived in homes that were likely to contain lead because of the housing age; based on publicly accessible information on housing age, 79.8% lived in homes built before 1978. Of the homes that were tested for lead because of their intervention group (n = 41), only 14.71% of homes tested actually had no lead present, and 75.6% of families who thought they did not have lead paint or reported they did not know if they had lead paint actually had lead paint in their home.

Mechanisms targeted by the intervention for reducing lead exposure are presented in Table 3 (brochure utilization and satisfaction) and Table 4 (cleaning frequency/quality and home repair efforts). Dusting, mopping, and

Table 2. Baseline risk for exposure from parental self-reports.

BLLs	Control (*n* = 22)	CK (*n* = 20)	RA (*n* = 20)	CK/RA (*n* = 24)
Housing age	M = 72.4 yrs (SD = 28.78	M = 76.6 yrs (SD = 30.24)	M = 81.4 yrs (SD = 26.3)	M = 73.9 yrs (SD = 27.06)
Playmate with elevated lead level	Y: 9.1% DK: 27.3%	Y: 5.0% DK: 40.0%	Y: 0% DK: 35.0%	Y: 4.2% DK: 50.0%
Pottery or ceramics made in other countries	Y: 9.1% DK: 4.5%	Y: 15.0%	Y: 10.0%	Y: 4.2% DK: 4.2%
Lead sealed plumbing	DK: 27.3%	Y: 5.0% DK: 15.0%	Y: 20.0% DK: 25.0%	Y: 4.2% DK: 54.2%
Lead painted homes*	DK: 22.7%	Y: 5.0% DK: 30.0%	Y: 25.0% DK: 40.0%	Y: 12.5% DK: 37.5%
Mini-blinds	Y: 77.3%	Y: 65.0%	Y: 50.0%	Y: 54.2%
Soil/dust from industry roadway	Y: 4.5%	Y: 25.0%	Y: 15.0% DK: 10.0%	Y: 16.7% DK: 4.2%
Metal-based jewelry	Y: 13.6% DK: 4.5%	Y: 15.0%	Y: 30.0%	Y: 16.7% DK: 4.2%
Lead-sealed cans/imported food items	Y: 0%	Y: 0%	Y: 5.0%	Y: 4.2%
Sum of risk variables	M = 1.1 (SD = 1.02)	M = 1.27 (SD = 1.08)	M = 1.95 (SD = 1.61)	M = 1.43 (SD = 1.03)
Job with potential lead exposure source	Y: 4.5%	Y: 5.0%	Y: 20.0%	Y: 12.5%
Hobby with potential lead exposure source **	pre: 27.3% post: 18.8%%	pre: 28.6% post: 11.1%	pre: 55.0% post: 25.7%	pre: 16.7% post: 6.7%

Note. Percent are provided for the number of participants who reported "Yes" (Y) and "Don't know" (DK); the remaining participants answered "No" for the risk category to reach 100%.

*Parenting reports are subject to poor validity. When comparing parents' report of lead paint in home to professional risk assessments of whether lead paint was present, 75.6% of parents had lead in their home but either reported they did not or said they did not know if their house had lead paint; the correlation between age of home and actual age was $r = 0.69$.

**Jobs listed that had potential for lead exposure were: plumber, pipe fitter, brass/copper, foundry, lead miners, lead smelters and refiners, demolition workers, auto repair, glass manufacturers, plastics manufacturers, radiator repair, gas station attendants, firing range instructors, policemen, battery manufacturers, steel welders/cutters, construction workers shipbuilders,bridge reconstruction workers, solid waste production, chemical and chemical preparation, printers

**Hobbies listed that are related to lead exposure were: glazed pottery making, target shooting at a firing range, reloading cartridges and lead shot, stained glass making, molding fishing sinkers, bullets, car or boat repair, home remodeling, furniture refinishing

vacuuming were reported as frequently done at the initial assessment, with toy cleaning less likely. Improvements demonstrated were not statistically significant between intervention groups. When cleaning changes were coded for those who received the cleaning kit, all participants reported some change in their cleaning habits (Table 4). The most common changes were reports of cleaning more thoroughly, using detergent containing TSP to clean, and changing locations where they cleaned (i.e., focusing more in children's rooms or in window and door frames). Some participants reported actions that were not suggested by the program, such as cleaning out their children's toys. The control group was most likely to make no repairs to their home and to spend the least amount on repairs as compared to the other three intervention groups.

Due to the study's two-factor design (i.e., receipt of cleaning kit and/or risk assessment), a 2 × 2 ANCOVA compared the group means for

Table 3. Group comparisons for brochure utilization, satisfaction, lead knowledge, and levels.

BLLs	Control (n = 22)	CK (n = 20)	RA (n = 20)	CK/RA (n = 24)
Participants read the brochures:				
by first phone call	50% (n = 11)	52.2% (n = 12)	60% (n = 12)	68.2% (n = 14)
ever	72.7% (n = 13)	78.3% (n = 18)	90.0% (n = 18)	95.5% (n = 21)
average months until read	2.35 months (1.98)	1.89 months (1.49)	2.00 months (1.56)	1.59 months (1.57)
For those who read the brochures:				
reported change made	66.7% (n = 10)	94.1% (n = 16)	82.4% (n = 14)	81.0% (n = 17)
reported as helpful	100% (n = 16)	100% (n = 18)	94.4% (n = 17)	100% (n = 21)
Knowledge				
pre-level	10.14 (2.70)	11.27 (3.13)	9.55 (2.86)	10.05 (1.89)
post-level	12.61 (2.38)	13.39 (2.00)	13.12 (1.36)	12.56 (1.72)
change[a]	−2.26 (1.80)	−2.55 (2.49)	−2.98 (2.15)	2.49 (1.80)
Blood (µg/dL)				
pre-level	5.02 (1.53)	5.25 (2.04)	5.75 (2.01)	5.18 (1.66)
post-level	2.87 (1.77)	2.72 (2.31)	2.70 (1.64)	2.76 (1.92)
change	−2.26 (1.80)	−2.46 (2.51)	−2.99 (2.15)	−2.54 (2.09)

Note. No group differences were evident across brochure utilization, satisfaction, lead knowledge, or blood lead levels. Standard deviations presented in parentheses. BLL = capillary blood draws for children's blood lead levels (µg/dl). CK = Cleaning Kit; RA = Risk Assessment. Change is average difference within intervention groups from pre to post score.

post-scores while controlling for initial scores for children BLLs and parents' lead knowledge (Table 3; Rausch, Maxwell, & Kelley, 2003). A power analysis based on previous effectiveness of loose paint stabilization and lead dust abatement (d = 0.3–0.4; Aschengrau, Beiser, Bellinger, Copenhafer, & Weitzman, 1994) suggested sufficient power should be achieved with 20–25 participants per cell. Covariates that are consistently related to lead exposure outcomes are ethnicity, child age, income, education, and season (Bernard & Mcgeehin, 2003). Parents' ethnicity (r = −0.30; p = 0.01) and child age (r = −0.38; p = 0.001) at the initial visit were retained as a covariate when evaluating the BLL model. Income, educational attainment, and the season during which the study began were also considered as covariates but were not related to the outcome variable and not included in the model. The same covariates were considered in the model evaluating parental knowledge; only education was retained (r = 0.37; p = 0.002).

When examining the children's overall changes in BLLs, only five participants showed any increase during the 6 months across which they participated in the project. These children increased an average of 1.88 µg/dL (SD = 0.98); two belonged to the control group, two to the cleaning kit group, and one to the risk assessment group. No children participating in the program increased above10 µg/dL and 91.8% had decreases in BLLs. However, no significant main effect or interaction in BLLs or knowledge was found between intervention groups. Regardless of group assignment,

Table 4. Reported cleaning changes in frequency and quality and home repair costs and efforts.

	Control (n = 22)	CK (n = 20)	RA (n = 20)	CK/RA (n = 24)
Cleaning frequency reported weekly or more often:				
Dusting Initial	88.9% (16/18)	83.3% (15/18)	88.9% (16/18)	90.5% (19/21)
Final	100.0% (15/16)	83.3% (15/18)	85.0% (17/20)	88.9% (16/18)
Mopping Initial	83.3% (15/18)	94.1% (16/17)	100% (18/18)	95.2% (20/21)
Final	93.8% (15/16)	94.4% (17/18)	95.0% (19/20)	94.1% (16/17)
Vacuuming Initial	100.0% (18/18)	94.4% (17/18)	77.8% (14/18)	90.5% (19/21)
Final	100.0% (16/16)	94.4% (17/18)	75.0% (15/20)	94.4% (17/18)
Cleaning toys Initial	22.2% (4/18)	38.9% (7/18)	22.2% (4/18)	28.6% (6/21)
Final	37.5% (6/16)	44.4% (8/18)	45.0% (9/20)	44.4% (8/18)
Change in reported cleaning quality:				
Using TSP	—	68.8% (11/16)	—	63.2% (12/19)
Using two-bucket system	—	25.0% (4/16)	—	47.4% (9/19)
Wet-dusts	—	37.5% (6/16)	—	37.5% (6/16)
Cleans more thoroughly	—	64.7% (11/17)	—	64.7% (11/17)
Got rid or cleans out toys	—	12.5% (2/16)	—	12.5% (2/16)
Began cleaning toys more often	—	6.3% (1/16)	—	6.3% (1/16)
Been dusting more	—	6.3% (1/16)	—	6.3% (1/16)
Changed cleaning locations	—	56.2% (9/16)	—	56.2% (9/16)
Post-intervention report of home repairs				
Average amount spent on repairs	\$5.00 (15.39)	\$150.56 (575.66)	\$76.13 (176.94)	\$107.95 (409.37)
No repairs made to home	81.0%	61.1%	50.0%	62.2%

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children's BLLs significantly decreased and parental knowledge significantly increased when combining all groups and conducting a repeated measures t-test. There was a significant increase in knowledge from the pre-test (M = 10.39; SD = 2.85) to the post-test (M = 12.92; SD = 1.90), an increase of 2.52 (95% CI [1.79 3.25]); $t(70) = 6.89$; $p < 0.001$, $d = 0.301$. Participants significantly decreased in BLL from the initial blood test (M = 5.28; SD = 1.85) to the final blood test (M = 2.70; SD = 1.94), a decrease of 2.58 μg/dL (95% CI [−3.05–2.10]); (BLL: $t[74] = 10.80$; $p < 0.001$, $d = 1.01$).

Intervention effectiveness: Inclusion of a post-hoc passive control

Results from the study suggested that all groups were successful in reducing children's BLLs, even the dissemination of EPA brochures for the active control. This reduction could not be definitively attributed to the intervention and could be explained by a regression to the mean or a naturally occurring reduction (Rabinowitz et al., 1976). The addition of a passive control group could dispel these potential internal validity threats and support that aspects of the intervention were responsible for the change. Children in the passive control averaged 4.69 μg/dL (SD = 2.66) on their original lead tests, with retests averaging 6.03 μg/dL (SD = 1.38), which was a significant increase, $t(\text{df} = 28) = -2.50$; $p = 0.02$; $d = 0.27$; 95% CI [0.24, 2.45]). A separate ANCOVA compared the passive control with the existing four groups: the active control, cleaning kit, home risk assessment, and combined group. The omnibus test was statistically significant, $F(4, 106) = 8.88$; $p < 0.001$, $\eta_p{}^2 = 0.291$; $R^2 = 0.295$. Contrast t-tests revealed a significantly greater reduction in BLLs for the children who had been associated with the intervention as compared to the passive control; all four comparisons were significantly different at $p < 0.001$ (95% CI [2.91 4.93]; $d_{corr} = -2.127$; Hedges G = 1.68).

Discussion

The current study was implemented prior to 2012 policy changes that addressed the long-held understanding of the consequences of any amount lead exposure to children (Bellinger & Bellinger, 2006; Betts, 2012; Needleman et al., 1990). Benefits exhibited across groups suggests practical significance, an important goal of prevention studies (Borkowski et al., 2007). The average decrease for participants (5.32 to 2.77 µg/dL) signified a reduction from the current reference level to a level slightly above the national average (Wheeler & Brown, 2013). Additionally, the majority of children (91.8%) had a decrease in BLLs. In comparison to the passive community control group, the four intervention groups were effective in decreasing BLLs, with the active control group being the most cost-effective approach to exposure reduction. Prior research has provided inconsistent evidence for educational interventions, suggesting that long-term effectiveness is more likely from home remediation than cleaning interventions (see Wilson et al., 2004; Yeoh, Woolfenden, Lanphear, Ridley, & Livingston, 2009). The current study provides encouraging results to support knowledge-based interventions targeting children with BLL less than 10 µg/dL.

Specific study design elements may have been influential in the success of the educational component in reducing children's BLLs. First, the brochures were provided to participants in the control group to represent the standard of care based on lead policies (US EPA, 2008); however, the dissemination of the brochures with the verbalized expectation that the families read them may have improved their typical efficacy. Additionally, multiple follow-up contacts through the monthly phone calls could have played a role in the brochures' effectiveness (Griffin & Dunwoody, 2000) and is in line with recent suggestions for monitoring exposure (ACCLPP, 2012).

The parent's knowledge of their children's precise BLL likely contributed to the overall decrease in BLLs and is also consistent with suggestions that lead results be communicated to families (ACCLPP, 2012). Previous federal and state policies did not require families to be notified of results from blood lead tests less than 10 μg/dL (Bernard, 2003); consequently, parents are often not aware if their child has been tested for lead and their children's precise BLLs (Polivka et al., 2006). Many parents in the current study were concerned their children's BLLs were greater than zero, which may have prompted a *teachable moment* as the parents were primed for health behavior change and more amenable to learning how to reduce lead exposure (McBride, Emmons, & Lipkus, 2003). Recent policy changes may already satisfy the study's implication that primary prevention efforts will be improved by making parents more aware of their children's level between 5 and 10 μg/dL.

Research has focused on the reduction of exposure and BLLs but has not focused on the mechanisms by which programs are effective; this study collected extensive information related to mediating factors that could have been influential in lowering BLLs. Due to the sample size, investigating the statistical effectiveness of these mechanisms was not possible but can provide important suggestions for future studies. For example, parents did not know whether or not risk factors were present and often incorrectly reported if they were (see Table 2). Particularly striking is the discrepancy between those who did not believe or did not know if they had lead paint in their home and those who actually did when measured by the risk assessment. This suggests parents are likely underestimating their children's risk for exposure and points to a potential target for primary prevention. Moreover, lead reduction attempts by families may have been beyond what was specifically focused on in the intervention. For example, parents consistently reported fewer hobbies related to lead across the intervention groups by the final assessment when this was not a focus of the intervention. In this manner, families may have been spurred towards change by the questions included in the intervention, as well as the actual intervention materials provided. Furthermore, the study suggested interventions may not need to target the frequency of cleaning but the quality in specifically targeting lead dust reduction (see Table 4). Finally, lead dust reduction from home repairs were more likely to be performed by the intervention groups; participants who received cleaning kits and risk assessments spent more money on improvements, were less likely to abstain from any repairs, and were more likely to accomplish repairs that would decrease exposure than the control group. It is important to consider how the intervention groups would receive more knowledge through the active learning experience provided by receiving the cleaning kit and watching the risk assessment.

Results must be considered in light of study limitations. BLLs were drawn from existing data and represent a mix of capillary and venous draws. Moreover, participants were not recruited to the study at standard lengths of time from their initial blood draw. The significant difference between the passive and active control group suggests that the study's educational component was effective in reducing BLLs (Lindquist et al., 2007) but does not provide a definitive explanation in what aspects of the study design were most effective and descriptive information on the passive control participants was lacking. While extensive training of the research team was done to maximize internal validity of the intervention, formal monitoring of the standardization of the research protocol was not completed and is recommended in future studies (Bellg et al., 2004).

Implications for practice

Results from this study are meaningful given the sample generalizes to families most at risk for lead exposure (i.e., lower SES, minorities; Dilworth-Bart & Moore, 2006). Furthermore, components of the intervention's design satisfy many of the baseline primary prevention efforts recently emphasized by the ACCLPP to serve the over 500,000 children now considered in need of intervention (ACCLPP, 2012). The merit of educational materials in combination with help from a service provider to digest the material, answer questions, and be accountable on actions taken should be further investigated as a cost-effective, family-centered, primary prevention tactic in light of our limited social service resources.

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Notes on contributor

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