Using behavior change to reduce child lead exposure in resource-poor settings: a formative study

M. N. Feit1*, A. Mathee2, T. Harpham3,4 and B. R. Barnes5
1Department of Health and Human Services, Office of the Assistant Secretary for Planning and Evaluation, Washington, DC 20201, USA, 2Environment and Health Research Unit, South African Medical Research Council, University of Johannesburg, University of the Witwatersrand, Houghton 2041, South Africa, 3Faculty of Human Sciences, London South Bank University, London SE1 0AA, UK, 4Epidemiology and Population Sciences Department, London School of Hygiene and Tropical Medicine, London WC1E 7HT, UK and 5Psychology Department, University of Johannesburg, Johannesburg 2006, South Africa

*Correspondence to: M. N. Feit. E-mail: monicafeit@yahoo.com

Received on December 10, 2013; accepted on August 6, 2014

Abstract

The objective of this formative research was to explore the acceptability and feasibility of changing housekeeping behaviors as a low-cost approach that may reduce childhood lead exposure in Johannesburg, South Africa. Using the Trials of Improved Practices (TIPs) methodology, modified housekeeping behaviors were negotiated with participants who chose the behaviors they wanted to try and then performed them in their homes over 4 weeks. Researchers interviewed them at the end of the month to understand their experience of trying out the behaviors. The modified behaviors offered to each participant were as follows: cleaning window sills with detergent and water, cleaning window sills more frequently, mopping floors with two buckets (one with soapy water for washing and one with clean water for rinsing), mopping floors more frequently, dusting surfaces with detergent and water and dusting surfaces more frequently. Participants found cleaning window sills with soap and water and cleaning them more often the most acceptable and feasible of behavior modifications. Environmental samples showed a significant reduction in lead dust on window sills. These findings can assist in the development of acceptable and feasible medium-term interventions to reduce childhood lead exposure in resource-poor settings until more robust health policies are implemented.

Introduction

Lead exposure, which prevents children from reaching their full potential by affecting their cognitive development, has remained a global problem for many decades. As health officials in developed countries increase their attention, commitment and resources to this problem, the global burden of lead has shifted to developing countries. South Africa is an example of a country that has been slow to respond to this threat. Lead exposure is preventable, but to date, few resources have been spent combating it, and little effort has been made to address it in Johannesburg, South Africa’s largest city, or elsewhere in the country [1].

Like many developing countries, South Africa does not have a robust set of environmental health protection laws in place. Compared with many developed countries, where action was taken in the 1970s, leaded gasoline was only phased out in South Africa in 2006, and legislation to control the use of lead in paint only came into full effect in July 2010 [2]. Children in South Africa are exposed to lead through a number of ways including mining, residual lead from gasoline, lead paint and the informal economic sector where lead is used in many activities (e.g. dismantling batteries, welding and automotive body work are often done in or near homes as a source of income and can expose children to lead) [3]. As a result, surveys indicate that large proportions of South African children have elevated blood lead levels [4, 5].
For example, in the suburb of Westbury in 2002, 75% of school children in the first grade had blood lead levels equal to or higher than 10 µg/dL—the widely accepted international action level at the time [5]. These were among the highest blood lead levels in Johannesburg. A follow-up survey in 2007 indicated that almost 30% of school children had blood lead levels of 10 µg/dL or higher (A. Mathee, unpublished results). It should be noted that there is widespread consensus that there is no safe level of exposure to lead and that global debate around a level at which intervention is recommended is ongoing. Recently, for example, the Centers for Disease Control and Prevention replaced the use of a static number (previously 10 µg/dL) with a reference value based on the 97.5th percentile of blood lead levels in US children aged 1–5 years, as measured by the National Health and Nutrition Examination Survey (NHANES); currently, the level is 5 µg/dL [6]. This reference value is to be updated every 4 years based on the most recent NHANES blood level data.

In Europe and the United States, interventions focused on changing behavior around household activities have shown some success in lowering blood lead levels [7–9]. However, the authors are not aware of any behavior change interventions that have been attempted to limit lead exposure among children anywhere in Africa.

Research examining behavior change in developing countries makes it clear that changing people’s behavior is a difficult task [10, 11], although there are lessons that can be learned from successfully implemented behavior change interventions. First among these is the need for formative research. In his chapter on formative research, Hernandez [12] defines it as ‘research that helps define the content of an intervention’ (p. 47). Formative research is an important first step in designing behavior change interventions, because understanding which behaviors are acceptable (people are willing to try them) and feasible (people are able to perform them) is critical to success [13, 14].

Unfortunately, most interventions designed to reduce lead exposure do not draw upon the behavior change literature. For example, Yeoh et al. [15] conducted a systematic review of housekeeping and educational interventions designed to reduce domestic lead exposure for the Cochrane Collaboration in 2008. By examining the intervention used in each of these studies, it is apparent that some sort of behavior change was sought. However, this was rarely acknowledged, and the authors did not use formative research to plan for behavior change that would be acceptable and feasible for the study participants. Although Yeoh et al. concluded that these interventions were not effective in reducing blood lead levels, this may be, at least in part, due to the fact that no formal behavior change approach was used, and no formative research was undertaken as part of the intervention design.

### Methods

This study used TIPs, a formative methodology developed by the Manoff Group in the United States [16]. Originally developed for nutrition programs, TIPs gave participants the opportunity to try new recipes in their own kitchens [17]. Over the years, the methodology has been applied more broadly to address indoor air pollution, insecticide-treated bed nets, family planning and hygiene [16], but it has retained its unique approach in facilitating behavior change by allowing participants to try out modified behaviors in their homes. In this study, TIPs was used to explore the acceptability and feasibility of behaviors that would reduce the exposure of children to lead dust in their homes. Because children’s exposure to lead begins in utero and children 5 years old or younger are most vulnerable to exposure [18], pregnant women and women caring for young children in their homes were the target population.

Participants were recruited in the waiting rooms at prenatal and pediatric clinics at Coronation Hospital in a low-income area of Johannesburg. The study area included the suburb of Westbury where children were documented to have elevated blood lead levels, as discussed in the previous section. Following the TIPs protocol, study participants were visited in their home three times over the
course of 4–6 weeks. At the first visit, they learned more about the project and selected one or more behaviors to try for 4 weeks. The second visit took place approximately 2 weeks after the first and was an opportunity for researchers to check on their progress. During the final visit, researchers used a semi-structured interview to learn about their experiences trying a different behavior as well as their intention about continuing the behavior. These interviews were recorded and transcribed. Figure 1 presents the steps involved in TIPs.

The 27 women who completed the study ranged in age from 16 to 50 with a mean of 25 years. Six of the women were pregnant at the start of the project, 13 of them were pregnant and had young children living with them, and 8 were not pregnant but the caregivers of young children.

The behavioral interventions offered to the participants in this study were the ones that had demonstrated reduced lead exposure in the home in previous studies. Although various approaches to lead exposure have been used in other studies, the behavioral interventions for this study centered on housekeeping. The behaviors emerged from focus group discussions, an earlier behavior trial and the published literature. There were six proposed behaviors that focused on three areas: cleaning window sills, mopping and dusting. The following modified behaviors were offered to each participant: cleaning the window sills with detergent and water, cleaning the window sills more frequently than she was currently cleaning them, mopping the floors with two buckets (one with soapy water for washing and one with clean water for rinsing), mopping the floors more frequently than she was currently mopping them, dusting surfaces with detergent and water and dusting surfaces more frequently than she was currently dusting. Participants could select more than one behavior.

Samples of floor dust and window sill dust were also collected at the first and final visits. Collection methods for floor dust and window sill dust were based on guidelines from the US Department of Housing and Urban Development [19]. Floor and window sill samples were collected from the room where the child or pregnant woman spent the most time during the day. If this room contained a carpet, then floor samples were collected from the kitchen. If there were no window sills, then only floor samples were collected. These samples were analyzed for lead content in the laboratories of the South African National Institute for Occupational Health (NIOH) using atomic absorption spectroscopy. The NIOH participates in national and international quality control programs for lead content analyses. Environmental samples were analysed using STATA. Because the distribution of the values was not normally distributed, the non-parametric Wilcoxon signed rank test was used to test whether lead levels changed before and after the intervention.

Qualitative data were derived from the interviews with participants. In the first interview, participants were asked about the condition of their house, possible exposure to lead, education and family income and current housekeeping behaviors.
the Reminder Visit, questions were asked about the new behavior the participant had selected—was she able to do it, was it easy or difficult, what did she like or dislike about it, did she think she would continue doing it? The final interview repeated the questions from the first interview, repeated the questions about the new behavior from the Reminder Visit and asked additional questions about perceived benefits of the new behavior, whether she would recommend the behavior to others and how she would describe the experience of trying the new behavior. Following the advice of Miles and Huberman [20], these interviews were transcribed and coded thematically. A startup list of codes was created from the literature before analysis. These codes were revised during analysis and resulted in a list of final codes. Microsoft Word was used to condense all of the codes for each interview and compare across cases.

Ethical approval was granted by the University of the Witwatersrand (Protocol M060360 and Protocol M070426) and by London South Bank University. Written informed consent was obtained from each participant. In one case where the participant was younger than 18 years, parental consent was also obtained.

**Results**

The study presented was formative and had three objectives. The first two were to explore the acceptability and feasibility of behavior change as a low-cost approach that may reduce childhood lead exposure in South Africa and the final objective was to determine whether dust levels in the home could be reduced through these behavior modifications.

Of the 30 participants in the first home visit, 27 completed the study. The three participants lost to follow-up were pregnant with an average age of 24 years. One participant lost interest, while the others moved out of the area. All of the participants agreed to try at least one new or modified behavior. Table I shows the six behaviors offered to the participants, the number that selected each of them and the number that was able to successfully perform them. Results are presented for the 27 participants who completed the study. In the case of cleaning window sills, only 24 results are presented as three houses did not have window sills. Cleaning window sills with detergent, cleaning them at least once a week and mopping the floor with two buckets were the most acceptable and feasible of the behaviors, with participants electing to try them more often than the other behaviors, and then reporting that they were able to successfully make the behavior change.

Most participants choosing the two-bucket mopping system were able to perform the modified behavior. However, when these findings were compared with the experiences of the participants, as expressed in qualitative interviews, a different picture emerged. Participants found it very difficult to use the two-bucket system and indicated that they would not continue the behavior. Mopping with the two-bucket system took extra time, required extra effort, and in some cases was made more difficult by the fact that participants only owned one bucket. One participant said she would have had to buy a new mop to try the mopping behavior so she did not try it (P28-3). The following excerpts illustrate the challenges of the two-bucket mopping technique:

*I was using one bucket but I had to like change the water around, take out the soapy water and put in clean water to reclean the floor properly...the two-step process is not a*
problem if you’re using two buckets . . . what I found to be more challenging is having to clean the whole floor with the soapy water and then taking out the water and putting in fresh water to make sure the floor is clean again (P18-3).

Researcher: Ok and how would you say it went to [use two buckets to mop]?
P9-3: It was a lot of work.
Researcher: Was there anything that you liked about doing it?
P9-3: No, because I have to push the furniture around so. I have to wipe first with the soap and then I have to wait to go back again with the clean water.

Researcher: For the floors, cleaning with two buckets, tell me how that went.
P1-3: It was a bit difficult.
Researcher: Ok. What was difficult about it?
P1-3: The two buckets. I had to mop twice.
Researcher: How much more time did it take?
P1-3: Half an hour.
Researcher: What would you say was the hardest thing about trying all these new behaviors, the window sills with soap and more often and mopping the floor differently? What was the hardest thing about that?
P7-3: Just the floor because it takes a bit longer.
Researcher: It was difficult.
P7-3: No, not really because I use that wonder mop. It just takes longer and because I have to wash the floor like twice. It’s like doing it twice.

The few participants who said they liked the new mopping technique also acknowledged that it was difficult.

P29-3: I’m the type of woman that likes to challenge something. Cooking or cleaning or anything, that’s why there was nothing for me not to say no. Yeah, I was excited like to learn something new about cleaning because it’s healthy and you think about your health and the baby’s health and so for me it was something good.

Researcher: You were up for the challenge?
P29-3: Yeah, I was up for it, yeah.
Researcher: Was there anything you liked about [using two buckets to mop]?
P12-3: Yeah, it was . . . it was a great experience for me.

Researcher: And what was good about it?
P12-3: To see that I can really do it.

Participants who agreed to try a modified way of cleaning their windowsills also reported much success and, unlike the experience of mopping with two buckets, qualitative interviews revealed that participants thought it was easy to clean windowsills with soap and water. They noted that cleaning windowsills did not require a lot of time or effort, and in many cases, they were already cleaning them with water; adding soap was not difficult. Although data on intention to continue the behavior were not systematically collected, in the interviews participants indicated that they would continue to clean their windowsills with soap and water.

One participant explained her experience with cleaning windowsills as the following:

Researcher: And how would you say it went cleaning the window sills?
P9-3: It was no problem.
Researcher: Was there anything you liked about doing it?
P9-3: Less dust.
Researcher: And before you were cleaning it, as I remember, less often. You weren’t doing it once a week, it was less often.
P9-3: Yeah.
Researcher: And just with the water. So what do you think made more difference, cleaning it once a week or cleaning it with soap? What made the most difference?
P9-3: I think cleaning it more often and with soap.
Researcher: Was there anything else you liked about . . . cleaning?
P9-3: No, it’s not a lot of work to clean window sills.

Another participant emphasized how easy windowsills were to clean:

Researcher: Now let’s talk about the window sills with soap, because you were just cleaning them with water before.
P20-3: With water first.
Researcher: Did you actually clean the windowsills?
P20-3: Yes I did. I did. It’s very easy and it’s clean. Because the soap is wiping up all of the dust and after that when you put it in clean water it’s easy . . . it’s easy to do that.

Researcher: Did it take a lot of time?

(continued)
And another participant stressed that this behavior change, in comparison to mopping or dusting, did not require a lot of work—‘it’s not so many window sills’ (P7-3). Thus, according to participants, cleaning window sills with soap and water was acceptable, feasible and a behavior they reported that they would be willing to continue.

The results of the environmental sampling allowed for triangulation of the data and strengthened the argument for using housekeeping as a behavioral intervention. Table II presents the lead concentrations before and after the intervention for window sill dust and floor dust taken from participants’ homes during the study.

Using the Wilcoxon signed rank test, the reduction in lead levels for window sill dust was significant ($P < 0.012$). The reduction in lead in floor dust was not significant ($P < 0.312$) but the trend was in the right direction.

The hazard level set by the US Environmental Protection Agency (EPA) [21] for lead in window sill dust is 250 $\mu$g/ft$^2$. South Africa has not set a hazard level. In the study, seven households had window sill dust that exceeded the hazard level for lead at the first visit. Three households had lead levels in the window sill dust that exceeded the hazard level at the final visit. The EPA [21] hazard level for lead in floor dust is 40 $\mu$g/ft$^2$, and only one sample from the first visit exceeded that level.

### Discussion

As the Cochrane Collaboration analysis [15] highlighted, little research has been done around designing or implementing interventions aimed at reducing childhood lead exposure in developing countries. The authors wrote ‘trials that look at suitable interventions in developing countries are also urgently required’ (p. 11). Developing countries bear the greatest burden of lead exposure. And with less legal oversight, fewer resources to allocate, higher rates of poverty, and in many cases (such as South Africa) a low-level of awareness, developing countries are already at a disadvantage in combating lead exposure.

This formative research, which contributes to the design of an intervention focusing on dust control through housekeeping and simultaneously takes local practices and preferences into account, differs from Yeoh et al. [15] by utilizing a behavior change approach to reduce childhood lead exposure. The studies cited by Yeoh et al. [15] focused on lead exposure, but failed to specifically engage behavior change as a way of reducing exposure. This work used a behavior change approach and was able to identify two concrete behaviors that may reduce children’s lead exposure in their homes—cleaning window sills with soap and water and cleaning them more frequently. As important as identifying acceptable and feasible behaviors, it is equally important to identify behaviors that are not feasible. In this case, mopping floors with two buckets was an acceptable behavior selected by most participants to try. But the experience of trying this modified way of mopping led the women to conclude that they did not like it—and the qualitative interviews in this research allowed this critical finding to come out.

These findings are promising for a number of reasons. There is a growing recognition that lead exposure causes harm to children at any level [22], and children less than 5 years are most at risk as their developing brains are more susceptible to lead absorption [18]. Children younger than 5 years are also more likely to spend most of their time at home and

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their developmentally appropriate behaviors, such as crawling on the floor and exploring their environment by putting things in their mouth, put them at risk for exposure to lead in the house. Studies, including this one, have shown that window sills often have the highest levels of lead in the house [23]. Further studies have linked interior leaded house dust to blood lead levels [24]. Therefore, it is reasonable to expect that reducing the lead in window sill dust through improved housekeeping could reduce children’s exposure to the metal and contribute positively to their health.

Through a housekeeping intervention, Rhoads et al. [9] were able to demonstrate a significant reduction in lead in window sill dust in the United States, as well as a significant reduction in blood lead levels. It is anticipated that a similarly structured intervention, using the results from this formative study, could produce similar results in developing countries.

Sampling window sill and floor dust at the first and final visits in this study presented an opportunity to test whether modified housekeeping behaviors could lower lead dust levels in an urban African environment. As mentioned earlier, dust samples from the window sills had much higher concentrations of lead than from the floor. Participants indicated in interviews that they cleaned their floors frequently even before the intervention. This may be reflected by the fact that only three participants opted to try mopping more frequently and none were able to do it. The less pronounced changes in dust levels on the floor may also be a result of the regular attention to cleaning the floors. Often a neglected area, window sills offered a promising target for lead dust removal. And the environmental samples showed that cleaning window sills with soap and water resulted in a significant reduction of lead dust. It should be noted, however, that this research was conducted among predominantly low-income women, which presents some challenges. One participant asked how important it was to buy detergent, ‘because I don’t have money for it’ (P24-3). The environmental samples also illustrate a limitation of the study. In some households, the structure did not include window sills. The suggested behavior modification would not work in these houses, which were typically the poorest in the sample.

It has been argued that using a behavior change approach to environmental health problems in developing countries can obfuscate the larger issue of service delivery and appropriate government intervention [25]. Behavior change is not the ideal approach to reducing childhood lead exposure in developing countries—preventing exposure is the ideal. However, in this context, where safely removing lead paint that is chipping and peeling and removing lead exposures from other sectors will be expensive and take time, behavior change may offer an appropriate response.

The TIPs methodology allowed researchers to identify an intervention that the target population is willing to try and able to perform. The developers of TIPs suggest sample sizes between 20 and 50 [16]. With 27 participants, this study fell into the suggested range. Recognizing the challenges inherent in changing behavior and the limitations of behavior interventions, it still remains that a behavioral intervention addressing lead exposure would meet an existing need in South Africa and other developing countries. Lead exposure continues to affect children, and in the absence of an adequate legal framework and other primary prevention strategies, changing the behavior of parents and caregivers may offer the best medium-term solution.

**Acknowledgements**

The authors acknowledge Inakshi Naik and her colleagues at the South African NIOH for their assistance in analyzing the lead samples. The authors thank each of the women who participated in this study.

**Funding**

This work was supported by the South African Medical Research Council.
Conflict of Interest statement

The opinions expressed in this article are the author's own and do not reflect the view of the Department of Health and Human Services or the United States government.

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