A Community-Designed Play-Yard Intervention to Prevent Microbial Ingestion: A Baby Water, Sanitation, and Hygiene Pilot Study in Rural Zambia

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Abstract. Malnourished children in low-income contexts usually suffer from environmental enteric dysfunction, which is damage to the intestines caused by chronic exposure to bacterial pathogens from feces hypothesized to contribute to stunting. Many intervention studies are piloting “Baby water, sanitation, and hygiene (WASH)” to help rural farming families reduce infant and young children’s (IYC’s) exposure to human and free-range livestock feces. One proposed Baby WASH intervention is a play-yard, which consists of a baby-proofed structure (i.e., playpen) that caregivers can place IYC into while doing chores around the household yard. This article describes the pilot development and assessment of a community-built Baby WASH play-yard and a plastic play-yard intervention with 21 caregivers of 6- to 24-month-old IYC in rural Zambia. A modified Trials of Improved Practices approach was used to conduct three visits in each household: an introductory visit during which play-yard use was explained, a second visit consisting of a semi-structured interview and a session of behavioral counseling, and a final visit which included a 2-hour observation of play-yard use. The second and final visits also included 24-hour recalls, and all three visits included spot observations of play-yard use. Reports from caregivers suggest that the community-built play-yard protected IYC from ingesting soil and livestock feces. Barriers to intervention use included caregivers’ WASH beliefs and practices, community reactions, and play-yard maintenance. More work is needed to examine the role of women’s time use in their home environment, community reactions to the intervention, and the biological efficacy to reduce microbial ingestion.

INTRODUCTION

Height stunting in infants and young children (IYC) is associated with risks of infectious diseases in childhood¹ and threats to cognitive development.² Analyses of improved dietary interventions suggest that a nutritionally adequate diet is necessary but not sufficient for reduction of stunting.³ Diarrheal disease and stunting are both concentrated in the first 2 years of life,^{4,5} but evidence that stunting cannot be explained by poor diet or by diarrhea alone has led Humphrey and others⁶ to hypothesize that environmental enteric dysfunction (EED)⁷ is the causal link between poor sanitation and hygiene, diarrhea, and stunting. Likely caused by fecal–oral transmission of microbes, EED is a subclinical and chronic gut injury that results in poor nutrient absorption, systemic immune system stimulation, and poor growth.⁸ Environmental enteric dysfunction’s possible transmission routes include oral contact with contaminated hands, drinking water, soil, utensils, food, and flies.^{9,10} Whereas the “hygiene hypothesis” suggests that some level of exposure to infectious pathogens is beneficial, EED is characterized by exposure to fecal–oral microbes that overwhelm and chronically activate the developing immune system of IYC.^{11,12}

Water, sanitation, and hygiene (WASH) interventions might help reduce EED as they prevent the transmission of harmful microbes by interrupting the path between fecal contamination and oral ingestion.^{6,11,13,14} A recent observational study in Bangladesh showed that children living in cleaner households had fewer markers of EED and were less stunted than children from households that were more contaminated with fecal bacteria.¹⁵ A Cochrane review of interventions to reduce

stunting also demonstrated that WASH interventions were most efficacious for reducing stunting in IYC 24 months old and younger.¹⁶ Although WASH interventions are believed to reduce the risks of EED, standard WASH interventions are not tailored to the unique fecal–oral transmission vectors of children aged less than 2 years. Infant and young children interact with the world around them through a multitude of sensory experiences, including exploring objects with their mouths. Infant and young children in rural, low-income contexts are frequently placed on the ground in spaces with free-range (and freely defecating) livestock and risk-ingesting dirt and feces during their routine exploratory mouthing behaviors.^{15,17–19} For context, a study in the United States found that the average hand-to-mouth frequency for children aged less than 5 years was 9.5 contacts per hour.²⁰ These exploratory behaviors might explain why some studies have linked livestock ownership to childhood stunting despite the positive potential nutritional effects of animal source foods.²¹ This sensory exploration opens IYC up to additional pathways of fecal–oral transmission that are not present for adults and, therefore, are not interrupted by traditional WASH interventions.¹¹

The term “Baby WASH” was coined to represent WASH interventions that address the specialized pathways of fecal–oral transmission for IYC to prevent EED.¹¹ Interrupting fecal–oral transmission requires providing the infant with a clean play and feeding environment in conjunction with caregiver education on the risks associated with playing in a contaminated environment.^{11,22} Caging free-range animals is one possible intervention, but investigative studies have found that corralling free-range livestock is culturally unacceptable and cost-prohibitive in rural, low-income, and subsistence farming contexts.^{23–25} Instead, Ngure and others¹¹ have suggested creating a hygienic environment for IYC through the provision of a protective enclosure in which the infant can play while separated from the risk of fecal–oral

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transmission, in tandem with education modules, handwashing, and safe water practices.²³ Examples of protective Baby WASH enclosures have included the Sanitation, Hygiene, Infant Nutrition Efficacy (SHINE) trial's use of plastic manufactured play-yards to prevent microbial transmission²³ and the Saving of Lives from Drowning project's use of locally manufactured, plastic play-yards in Bangladesh to prevent drowning.²⁶ Notably, these plastic play-yards are both novel to the community and prohibitively expensive to households outside of the context of a large research study. Therefore, new and locally sourced Baby WASH play-yard interventions are needed to reduce fecal–oral transmission risks for IYC in low-resource contexts.

Zambia is one of the African countries with the highest burden of undernutrition for young children²⁷—40% of Zambian children less than the age of 5 years are stunted—and thus stands to benefit from improved interventions to prevent microbial ingestion and stunting. We piloted the design process, acceptability, and feasibility of a novel, community-built Baby WASH enclosure to protect IYC from fecal–oral transmission in their household environment in rural Zambian communities and compared the community-designed enclosure with a plastic manufactured play-yard. Protecting IYC from fecal contamination in the household requires an enclosure that is safe, feasible, locally acceptable, and meets the child's developmental needs for exploration and interaction.²² We used a socially conscious and evidence-based design process to create an acceptable and locally produced Baby WASH enclosure intervention. This human-centered design process involves community members in the planning of the design and educates them on how to use the design.²⁸ We aimed to design, produce, and evaluate a Baby WASH enclosure that was small scale, low cost, and integrated into the local context. We also aimed to provide a framework for future interventions in other contexts. This study presents a new, locally derived Baby WASH play-yard to protect IYC from the risks of fecal exposure in the rural household environment.

MATERIALS AND METHODS

This pilot of a community-built Baby WASH play-yard for IYC was conducted within CARE USA's Nutrition at the Center (N@C) program in rural Zambia. Nutrition at the Center is a 5-year integrated nutrition project designed to improve nutritional outcomes for mothers and IYC (age 0–24 months) through interventions in nutrition and health, food security, WASH, good governance, and women's empowerment. The study took place in six rural villages participating in the N@C program located within 2 hours of the city of Lundazi. All villages had an economy based on subsistence and small-market agriculture. Households, with houses primarily made of mud-brick walls with thatched roofs, had separate structures for sleeping and cooking surrounded by a dirt or sand yard in which most household activities took place. Households were clustered together in a village with different families living in close proximity. Inclusion criteria were households participating in the N@C with any free-range small livestock (e.g., chickens, goats, and pigs) and IYC 6–24 months old. After discussion at the village level, the village leader gave verbal consent for research activities to take place and adult caregivers gave oral consent to participate in the study and receive the intervention. The Institutional Review Board (IRB) of Cornell University (ref. no. 1405004690) and the University

of Zambia Biomedical Research Ethics Committee (ref. no. 013-11-13) approved this study.

Baby WASH education. Education modules were modeled after Baby WASH education modules in the SHINE trial²³ and modified with input from CARE Zambia, to fit both the cultural context and the community-group model of the N@C intervention. The modules were delivered during a single session in each of the participating villages. The five main behavior change messages disseminated to mothers were the following:

1. Safely dispose of all animal and human feces
2. Wash hands with soap or ash after fecal contact and before preparing food, eating food, or feeding children
3. Protect children from ingesting soil and animal feces
4. Freshly prepare children's food or reheat to boiling before feeding
5. Give children (after 6 months of exclusive breastfeeding) treated drinking water

Designing the Baby WASH play-yard. After the Baby WASH education module was delivered through N@C community support groups, CARE staff facilitated a participatory co-design session with the village leaders and community members from three of the six participating villages. A research team with expertise in design, child development, and international nutrition developed the basic design requirements of the community-built Baby WASH play-yard to meet U.S. and international safety standards and conventional play-yard designs (Table 1). For example, safety standards such as those set by the U.S. Consumer Product Safety Commission for articles intended for use by children were used in the design to ensure that the design did not promote lacerations, puncture wound injury, aspiration, ingestion, amputation, or other injury.^{29,30} The design requirements for the community-built play-yard included the following:

1. Separation of the infant from contaminated soil in the household yard
2. Physical safety for the infant
3. Visibility into the enclosure while the caregiver performs household chores
4. Accessibility for caregivers and others to get in and out of the enclosure
5. Space for the infant to crawl and walk inside the enclosure
6. Reflection of the community context
7. Visual stimulation for the infant while inside the enclosure

Design discussions and decisions were conducted in collaboration with key community partners and stakeholders such as local CARE staff members, community health volunteers, local manufacturers, and local craftspeople. The team explored the option of plastic play-yard enclosures available for sale in Zambia, but there were none. Among the design features considered were the use of woven sticks or mud brick for the play-yard wall, the necessity of a roof over the enclosure, material selection and construction of a mat to keep IYC off the ground, the size of the enclosure, and painting of the inside of the enclosure. In the end, a mud-brick structure with a thatched roof was deemed the most acceptable design. The basic mud-brick design mimicked both local kitchens and typical structures in rural communities that men would use to meet and rest, provided critical shade to the infant while inside the enclosure, and was physically sturdy. This basic play-yard and mat design was further developed with CARE Zambia

TABLE 1
Community-built Baby WASH play-space safety considerations

Potential risk	Design guideline to address risk	Design to address risk
Choking	No parts shall fit into a cylinder 2.25 inches long by 1.25 inches wide that approximates the size of the fully expanded throat of a child aged less than 3 years.	No components of the community Baby WASH play-yard are removable and thus do not present a choking hazard to children aged less than 3 years.
Entrapment: fingers and toes	The minor dimension of 0.210" and the major dimension of 0.375" prevent entrapments in accessible holes in products intended for children 6–24 months of age.	The community Baby WASH play-yard was designed without openings and thus does not provide accessible holes to remove the risk of entrapment.
Entrapment: head	Openings must be less than 3.5" or greater than 9".	
Pinching or shearing	Scissoring, shearing, or pinching that may cause injury shall not be permissible when the edges of the rigid parts admit a probe that is greater than 0.210 inches (5.30 mm) and less than 0.375 inches (9.50 mm) diameter at any accessible point through the range of motion.	The community Baby WASH play-yard is built in place, without swinging doors or openings to remove the risk of pinching or shear injuries.
Cuts, sharp edges	There shall be no hazardous or sharp points that could break skin.	The Baby WASH play-yard is constructed from a solid surface of rammed earth and does not have hazardous or sharp points.
Toxin exposure	Ensure parts contain no lead. Avoid the use of formaldehyde-treated wood products or other volatile organic compounds. Choose plastics that use polyethylene (#1, #2, and #4) and polypropylene (#5), which require the use of less toxic additives and are non-chlorinated.	The Baby WASH play-yard structure is constructed from locally sourced and natural materials, including untreated wood, local mud and dirt materials, and locally grown straw for thatching. The play mat is constructed of recycled polypropylene bags from corn meal distributors.

WASH = water, sanitation, and hygiene.

staff members who had knowledge in local building materials and methods to maximize both infant safety and ease of construction by rural households.

The intended design was then shown to participating communities by CARE staff and community health volunteers

(Figures 1 and 2). Community members and village leaders were encouraged to use local skills to identify the opportunities and risks of design. CARE Zambia staff members worked with village leaders to ensure that workshop groups were both representative of the community and sensitive to

Play Yard Exterior Structure Guidelines

Interior Section of Play Yard Structure

FIGURE 1. Proposed design of community Baby water, sanitation, and hygiene play-yard intervention, using traditional architecture and building materials. This figure appears in color at www.ajtmh.org.

FIGURE 2. Proposed location of community-built Baby water, sanitation, and hygiene play-yard, relative to a typical household yard. This figure appears in color at www.ajtmh.org.

gender parity. When building the first test model of the community-built play-yard, a large group of community members and the village leader came to witness the building and participate in a meeting about the play-yard. CARE staff members took pictures and created pictorial representations of the final design to communicate the design to the families designated to receive the community-designed solution.

The final design of the community-built play-yard was based on traditional circular architecture with traditional building methods such as wooden vertical columns, plastered earthen walls, and thatched roofs. Each household was supplied with a mat made of woven plastic grain bag materials that spanned the floor of the play-yard. Community members assisted the household in building a mud-brick play-yard structure. Construction labor was divided in traditionally

FIGURE 3. Photos of community-built Baby water, sanitation, and hygiene play-yard and woven polypropylene mat. This figure appears in color at www.ajtmh.org.

gendered tasks, with men constructing the wooden supports and women constructing the mud wall, thatching the roof, and painting the structure. The play-yard was approximately 3 m in diameter and built in the style of traditional kitchens with a 1-m high mud-brick wall. The structure also included an open thatched roof held up with wooden pillars (Figure 3). The play-yards were built to follow international safety standards. After the community play-yard design was approved by the Cornell IRB, caregivers were counseled about pre-identified WASH issues and invited to try the protective play-yard intervention. Households that consented to participating received a locally made polypropylene mat and constructed the play-yard in the center of each household yard with the help of nearby neighbors.

Control Baby WASH play-yard. To serve as a comparison group, households from the three remaining villages were invited to try a plastic play-yard manufactured in the United States by North States Industries. This play-yard, identical to the play-yard used in the SHINE trial in Zimbabwe, is brightly colored, plastic, sturdy, moveable, and allows children to move around inside.²³ The plastic play-yards were 0.66 m in height (26 inches) and consisted of eight openwork panels that enclosed an area of 3.20 m² (34.4 square feet) (Figure 4). Participating villages were split based on proximity, such that the community play-yard households would be in different villages far enough away from the villages receiving the plastic play-yards to ensure that the different interventions would not influence each other. The plastic play-yard and locally made polypropylene mat were delivered after education modules had been delivered by community health volunteers.

Assessing the Baby WASH play-yard. A modified Designing by Dialogue approach³¹ was used to conduct a multiple-week pilot trial of the community-built play-yard and the plastic play-yard interventions with households across the six participating villages. This approach included a convergent mixed-methods design, with qualitative and quantitative data collected concurrently, analyzed separately, and interpreted together.³² Oral consent was obtained from the caregivers before constructing the play-yard in community play-yard group and from the plastic play-yard group at the beginning of the first research visit. After oral consent was given by the caregivers, three assessment visits were conducted in each household: an introductory visit during which play-yard use was explained and a spot observation and short interview of

household hygiene practices and beliefs were conducted, a second visit consisting of a semi-structured interview and a session of behavioral counseling, and a final visit which included a 2-hour observation of play-yard use. The second and final visits also included 24-hour recalls and spot observations of play-yard use. A timeline of the process of introducing education modules, design workshops, and household visits can be viewed in Figure 5.

The key assessment objectives were to characterize how households:

1. used the play-yard;
2. found the play-yard and mat feasible;
3. cleaned the play-yard and mat;
4. followed safety protocols around the play-yard, including adult supervision at all times;
5. perceived their family's and community's support of the play-yard.

A researcher visited each household three times over 2 weeks to assess the uptake of Baby WASH practices and play-yard use. Observations were conducted by trained observers fluent in Tumbuka with detailed observation guides, checklists, and pre-written semi-structured interview questions with detailed follow-up questions. The first visit included an introduction to the play-yard and mat intervention and a review of key safety behaviors, described in the following paragraphs. Observation visits were conducted as surprise visits, to reduce the risk of caregivers altering behavior before spot observations. Researchers conducted spot observations at the beginning of each household visit to record the number of children and objects inside the play-yard. In addition, a researcher observed if the play-yard, mat, children, and/or objects were visibly dirty or without visible dirt, following the methods of Ngure et al.³³

The first 24-hour-recall was conducted on the second visit to the household and the second 24-hour recall was conducted on the third visit to the household. Both 24-hour recalls occurred after the spot observation. In the 24-hour recall of play-yard use, researchers asked caregivers to report on every time whether the IYC was placed in the play-yard on the previous day's morning, afternoon, and evening. Researchers probed for reasons why the caregiver was using the play-yard, what the caregiver was doing during play-yard use, who was watching the IYC in the play-yard, how long the IYC spent in the play-yard, what the activities and mood of the IYC were in the play-yard, reasons for taking the IYC out of the play-yard, and where the play-yard was located (for plastic play-yards only). After the 24-hour recall on the second visit, researchers conducted semi-structured interviews that explored how the play-yard was used, caregiver likes and dislikes about the play-yard, cleaning behaviors, and caregiver perceptions of household and community reactions to the play-yard.

Safety behaviors were introduced with the play-yard and researchers reiterated these safety behaviors through targeted counseling during observational visits. Researchers identified undesirable safety behaviors from semi-structured interviews and 24-hour recall responses about play-yard use. Counseling was provided by research staff with semi-structured counseling guidelines at the end of the second research visit. Researchers conducted counseling sessions if the caregiver was engaging in unsafe or undesirable Baby

FIGURE 4. Plastic Baby water, sanitation, and hygiene play-yard intervention, North States Industries, Inc.

FIGURE 5. Timeline of education module introduction; Baby water, sanitation, and hygiene play-yard builds; and research assessment visits. This figure appears in color at www.ajtmh.org.

WASH behaviors observed at the beginning of the visit, during the 24-hour recall of play yard use, or during the interview with the caregiver. Undesirable behaviors were defined as animals in the Baby WASH play-yard, the presence of a dirty mat or play-yard interior, building or using the play-yard close to a well or fire hazard, and covering up the play-yard with a blanket (a smothering hazard). Caregivers were counseled on providing clean toys that did not provide choking or smothering hazards. Caregivers were also counseled to sweep the community play-yard floor and wash the provided mat (with both play-yard types) with water and soap. Food left in the play-yard was also discouraged, both to prevent choking hazards and to prevent industrious, free-ranging livestock (goats and chickens) from scaling the play-yard walls to access the food. After identification of possible safety risks, the researcher present counseled the caregiver on how to minimize safety risks with specific, predetermined behavior modifications.

Adult supervision of the infant while the infant was in the play-yard was emphasized throughout the pilot study. Leaving the child in the play-yard for extended periods of time, defined by researchers as any episode exceeding one and a half hours, and lack of adult supervision of IYC in the play-yard were flagged as safety hazards. Following the guidelines of physical neglect and lack of supervision in the modified maltreatment classification system, "low-severity lack of supervision" is defined as the caregiver failing to provide adequate supervision for short periods of time with no immediate danger in the environment.³⁴ Adequate supervision depends on the age and developmental stage of a child.³⁴ Because IYC need active supervision and consistent social interaction from a caregiver, leaving IYC in the play-yard for long periods of time has implications for their emotional and social development.³⁵ Although no standard of age-appropriate supervision time exists,³⁴ this study encouraged caregivers to use the play-yard for periods of ~90 minutes or less to prevent the play-yard from becoming an isolating structure between the child and caregiver.

At the third visit, a 2-hour observation of play-yard use and infant mouthing behaviors was conducted. The researchers observed each instance of the IYC mouthing soil or feces and noted the position of the IYC as either inside or outside of the play-yard and on or off a mat. In addition, with each mouthing behavior, the researcher observed the caregiver's reaction to the IYC to note if the caregiver saw the mouthing behavior and stopped it. In total, researchers conducted three spot observations, two 24-hour recalls of play-yard use, one semi-structured interview, and one counseling session in each of the households.

Data analysis. Text data from interviews of caregivers were analyzed thematically and reviewed by a second researcher to identify frequently stated problems, difficulties and benefits of play-yard use, reactions from community members, care and maintenance of the play-yard, perceptions of daily use, and children's reactions to time in the play-yard. Summary statistics were conducted in SPSS statistical software version 24 (IBM Corporation, Armonk, NY).

RESULTS

Ten households received the community-built Baby WASH play-yard pilot intervention (community play-yard) and twelve households received the plastic play-yard intervention. One household in the plastic play-yard intervention was lost to follow-up after the first research visit because of the household's travel to the capital during research visits 2 and 3. Results from the remaining eleven households with the plastic play-yard intervention are reported. The mean age of the IYC at the start of the intervention was 15.5 ± 4.4 months in the community play-yard group and 14.9 ± 4.3 months in the plastic play-yard group. Outside of one grandmother in the community play-yard group, all primary caregivers in both groups were the target IYC's mother. All but one IYC were able to crawl and 14 IYC were able to walk on their own. One household in the community play-yard group reported not having access to a latrine and all of the remaining households in both groups reported access to a latrine.

Setup for the community play-yard. Building the community play-yards took approximately 1 week, which included cutting wood and collecting grass for construction materials. Community members reported that the construction would have taken longer if it was a single family building the structure, and community participation alleviated the construction burden as one caregiver summarized

It was easy [to build] because we had helped one another with our friends. There was nothing difficult. [Community play-yard caregiver]

Half of the caregivers reported no difficulties and half of the caregivers reported some difficulties in play-yard construction. Difficulties in construction included cutting grass and trees and constructing of the structure's roof. No caregivers commented on issues of the community play-yard taking up too much space in the household courtyard area or its worth relative to other uses of space. One caregiver noted that the IYC's grandparents wanted a community play-yard built in their household yard for convenience when watching the infant.

Setup for the plastic play-yard. Caregivers noted that they found the play-yard easy to move and put together and liked the compact size of the plastic play-yard:

It is easy because it only takes a small space; it is not large to take up space in the house. [Plastic play-yard caregiver]

Two caregivers noted that the plastic play-yard was difficult to open and close and two caregivers expressed difficulties cleaning the play-yard when it was dirty. One caregiver commented that it would be difficult to keep older IYC out of the play-yard. The remainder of the caregivers expressed no negative reactions to the play-yard. Multiple caregivers reported a need to shift the plastic play-yard for the following reasons: when chores were finished, to bring the play-yard to the field, to prevent vandalism, and to move the play-yard either out of the sun to protect the IYC from getting burned or into the sun to prevent the infant from getting cold. One caregiver described the need to move the plastic play-yard as follows:

It only becomes a problem when the play yard is in the sun because you need to move it into the shed but again when it is in the cold you need to put it in a warm place. [Plastic play-yard caregiver]

Characterizing use of the Baby WASH play-yards. All Baby WASH play-yards were observed to be without visible dirt on arrival. Although no visible human or poultry feces were observed in the kitchen or yard at the first visit to the community play-yard households, poultry feces were observed in the kitchen areas of six of the plastic play-yard households. During 24-hour recalls of play-yard use, caregivers from both groups reported they used the play-yard most often in the morning and in the afternoon (Table 2). In the community play-yard group, households used the play-yard between one and four times per day in the first 24-hour recall (median = 1.5) and between two and five times per day in the second 24-hour recall (median = 2.5). In the plastic play-yard group, households

used the play-yard between zero and five times per day in the first 24-hour recall (median = 2) and between one and nine times per day in the second 24-hour recall (median = 2.5). The time duration of use episodes ranged from 10 minutes to 3 hours.

The top three caregiver activities that initiated the use of both the community and the plastic play-yards were cooking, cleaning, and drawing water (Table 3). Although most caregivers reported that the play-yard helped with their chores, one caregiver noted that the community play-yard introduced additional chores that reduced the amount of time the caregiver could spend in the field. All caregivers in the community play-yard group reported cleaning the play-yard and most often used a broom to sweep the play-yard several times a day. All but two of the caregivers in the plastic play-yard group reported cleaning the play-yard. About half of the community play-yard caregivers ($N = 4$) and most of the plastic play-yard caregivers ($N = 8$) reported cleaning the mat. In both groups, there were mixed responses of the task of cleaning the mat:

[The mat is] difficult to wash when it is dirty. [Community play-yard caregiver]

[Cleaning the mat] takes very little time. [Community play-yard caregiver]

Common positive community play-yard behaviors were sweeping the play-yard/mat ($N = 9$), building the play-yard close to the household ($N = 9$), and not building the play-yard next to an open well, fire, or other hazards ($N = 9$). Common positive behaviors for the plastic play-yard group were setting up the play-yard close to the household ($N = 10$) and not allowing chickens or other animals in the play-yard ($N = 10$).

The two most common hazards in the community play-yard group were the presence of dirty toys in the play-yard ($N = 2$) and insufficient adult supervision with the play-yard ($N = 1$). In the plastic play-yard group, the two most common hazards were a visibly dirty play-yard or mat in the play-yard ($N = 4$) and setting the play-yard up close to an open well, a fire pit, or other hazards ($N = 4$). No caregivers reported animals getting into the play-yard with the IYC in any 24-hour recall.

Caregivers from both groups used the play-yards for extended periods of time, defined by researchers as any episode exceeding one and a half hours (Table 2). Counseling on using the play-yard for shorter periods of time was conducted with any household using the play-yard for extended periods of time. Only one caregiver (in the plastic play-yard group) reported that the IYC were not supervised by an adult while in the play-yard and the caregiver agreed to be near the play-yard to supervise the baby after counseling.

Researchers observed additional objects inside the community-built play-yard in three households during the first spot observation: a plastic toy, a plate with maize, and a "chitenge" (fabric similar to sarong, often worn by women and wrapped around the chest, waist, or head, and used often as both a baby sling and a baby mat on the ground). During the final visit, none of the community play-yards had any additional objects inside. In the plastic play-yards, three households had objects inside on the first spot observation and seven households had objects in the final observation. The objects in the plastic play-yards included household items, toys, a chitenge, and food.

TABLE 2
Time of day and length of use of Baby WASH play-yard

	Community play-yard		Plastic play-yard	
	Number of use episodes		Number of use episodes	
	24-hour recall 1 (N = 10)	24-hour recall 2 (N = 10)	24-hour recall 1 (N = 10)*	24-hour recall 2 (N = 10)†
Episodes: time of day				
Morning	11	18	11	24
Afternoon	7	14	10	8
Evening	—	5	—	—
Duration of use				
< 60 minutes	3	20	6	14
60–90 minutes	4	14	12	6
> 90 minutes	11	8	4	10

WASH = water, sanitation, and hygiene. Discrepancies between the total numbers of episodes (time of day vs. duration of use) are because of caregivers being either uncertain when in the day they used the play-yard or unable to report how much time they used the play-yard for during certain recalled episodes.

* One caregiver reported not using the play-yard at all when prompted for the 24-hour recall, as the mother had taken the baby to the grinding mill with her.

† One caregiver reported not using the play-yard at all when prompted for the 24-hour recall, as the baby was sick.

The IYC experience inside of the play-yard. When in the play-yard, caregivers from both groups reported that the IYC was often playing with toys or playing with other children (Table 3). Caregivers most often took the child out because the baby was crying, it was time to wash the baby, the baby had defecated, or the caregiver was leaving the household to go to the field or draw water. Further detail of play-yard use is shown in Table 4.

Caregivers from both groups reported that the IYC activities inside the play-yard were different from the IYC activities outside of the play-yard. Although caregivers acknowledged these differences in activity, they did not express concern about it or define it as a drawback to the play-yard. Some caregivers from both groups reported that when the IYC were in the play-yard, they interacted with fewer older children (loosely termed here as playmates) and moved less physically than when they were outside of the play-yard:

When he is inside no older children go inside because I stop them so he plays with those of his size but when he is outside the play yard he can play with anyone. [Plastic play-yard caregiver]

Despite this, all caregivers but one (from the plastic play-yard group) reported playmates inside of the play-yard during multiple episodes of use and researchers also observed multiple playmates in the play-yard in most household visits. The playmates' ages ranged from 20 months to 11 years.

Caregivers from both groups reported that playmates enjoy getting in the play-yard and the target IYC also enjoyed other children in the play-yard:

They [the older children] just sit and admire the inside. Just to say we also want to sit here. [Plastic play-yard caregiver]

Perceptions of the Baby WASH play-yard. Caregivers reported positive qualities of both types of play-yards. Caregivers reported that the drawings inside the community play-yard were a positive feature. Other positive features of both types of play-yards included the play-yards' ability to protect the infant from fire, water (drowning), illness, eating soil, and diarrhea. In addition, both groups noted that the play-yard was convenient when the caregiver was doing chores around the household:

[The play yard is] Close to the [kitchen] which I use for cooking. Because it is close, I am able to look at the child when I am cooking. [Community play-yard caregiver]

For caregivers with the plastic play-yard, safety concerns included the risk of children climbing out of the play-yard and the perceived durability of the play-yard, as summarized as follows:

The only worry that we have is that the child climbs on the sides of the play-yard, and we fear that if he falls he could hurt himself. . . [Plastic play-yard caregiver]

TABLE 3
Reported activity of child inside of the Baby WASH play-yard

Child's activity	Community play-yard, number of episodes		Plastic play-yard, number of episodes	
	24-hour recall 1 (N = 10)	24-hour recall 2 (N = 10)	24-hour recall 1 (N = 10)*	24-hour recall 2 (N = 10)†
Playing with household-made toys	4	27	11	21
Playing with others	2	5	10	8
Eating food	—	—	1	4
Sleeping	1	2	2	—
Playing on own	2	—	—	3
Looking at pictures	2	7	—	—
Nothing	7	—	—	—
Total reported child activity episodes across all households	18	41	24	36

WASH = water, sanitation, and hygiene.

* One caregiver reported not using the play-yard at all when prompted for the 24-hour recall, as the mother had taken the baby to the grinding mill with her.

† One caregiver reported not using the play-yard at all when prompted for the 24-hour recall, as the baby was sick.

TABLE 4
Prompts for use of Baby WASH play-yard

Activity prompting Baby WASH play-yard use	Community play-yard		Plastic play-yard	
	Number of use episodes		Number of use episodes,	
	24-hour recall 1 (N = 10)	24-hour recall 2 (N = 10)	24-hour recall 1 (N = 10)*	24-hour recall 2 (N = 10)†
Cooking	6	18	4	4
When going out (drawing water or to the field)	5	5	8	1
Resting/leisure/just sitting	–	3	1	3
Not to eat soil/not to get dirt	–	–	2	3
Cleaning/sweeping/household upkeep	1	6	6	8
Laundry	5	3	3	1
Washing/washing plates	2	4	3	3
Chopping firewood	–	1	2	–
Washing nappy	–	1	–	–
Bathing	1	1	1	–
Playing	–	–	–	10
Sleeping	–	–	–	1
Feeding	–	–	–	1
Total use episodes across all households	20	42	30	35

WASH = water, sanitation, and hygiene.

* One caregiver reported not using the play-yard at all when prompted for the 24-hour recall, as the mother had taken the baby to the grinding mill with her.

† One caregiver reported not using the play-yard at all when prompted for the 24-hour recall, as the baby was sick.

Caregivers from both groups reported that the child was clean when inside the play-yard and that the child ate dirt and soil when outside of the play-yard. This caregiver report was corroborated during a 2-hour observation at the final visit: researchers observed one instance of IYC inside of a community play-yard mouthing soil or stones. Researchers observed five households in which IYC mouthed soil or stones once or twice outside of the community play-yard. Researchers observed three IYC in the plastic play-yard group mouth animal feces and four IYC mouth soil or stones, although all of these observations occurred when the target IYC were outside of the plastic play-yard.

In both groups, all caregivers reported either positive or neutral thoughts from family members regarding the play-yard. However, some caregivers reported negative community reactions to the intervention. Five caregivers with the community play-yard and three caregivers with the plastic play-yard indicated that neighbors shared disapproving or skeptical thoughts regarding the play-yards, particularly from other mothers in the community. One participant explained that they built the community play-yard close to the house to prevent other people from vandalizing the structure by setting it on fire. Other community members believed that eating soil helps the baby's guts and intestines and did not see the benefits of the play-yard. Some caregivers reported that disapproving opinions from community members came from jealousy. Furthermore, other community members disapproved of the added work of cleaning the play-yard and the use of soap for Baby WASH behaviors. In the face of community members' disapproval, caregivers in both groups reported the benefits of using the play-yard. The comments below were typical from both groups:

[Others] say the time we take to put the child in [the play-yard], we waste time that we could be doing other work, and when we are washing we are wasting our soap because that soap is never replaced. These are the difficulties that 'kill' them. [Community Play-Yard Caregiver]

[The other mothers] are also happy, they even suggest carrying it to go and pitch it at their place so that they can play. Because I think they like the way the child looks when inside the play yard because he is always clean even after bathing him after a long time. There are others who say [the researchers] are just distracting you. But I tell them that it is because they have stopped bearing children that is why they say so. They want to injure my feeling, because they have not seen the benefits of the play yard. [Plastic Play-Yard Caregiver]

Household WASH attitudes and knowledge. In semi-structured interviews conducted roughly a month after villages participated in community support groups with the SHINE-adapted Baby WASH educational materials,^{23,36} caregivers from both groups reported that infant geophagy had negative consequences, such as contributing to poor child growth and disease. Notably, two caregivers with the community play-yard and one caregiver with a plastic play-yard also reported that eating soil helps the baby's guts and intestines. All caregivers agreed that feces should be disposed of in latrines or pits away from IYC. Caregivers from both groups disliked the suggestion of disposing waste water from washing basins because of its impracticality and inconvenience and instead preferred the common practice of using waste water for handwashing. The following quote illustrates the disliked demands of WASH practices:

When we wash nappies we should throw the wash water far away and when we come from using the toilet we need to wash our hands. These are the things that do not make us happy. [Plastic Play-Yard Caregiver]

DISCUSSION

There are a number of research interventions that use the Baby WASH framework to protect IYC from fecal-oral transmission, and the affordability and scalability of these interventions

are critical for future reductions in EED.^{23,37,38} This study is the first to design, implement, and investigate a community-built Baby WASH play-yard to reduce infant consumption of dirt and feces in sub-Saharan Africa. This study draws on participant experience and pinpoints barriers and facilitators to implementing a community-built play-yard intervention. This study demonstrates that community-built Baby WASH play-yards can be a feasible alternative to plastic play-yards to reduce microbial ingestion through dirt in the rural household.

This pilot study fills a gap in the current literature by presenting important safety and programmatic considerations, facilitators and barriers to use, and acceptability and feasibility of building and using a community-built Baby WASH play-yard.

Community-built Baby WASH play-yards are a feasible alternative to plastic Baby WASH play-yard interventions.

The community-built and plastic Baby WASH play-yards have different physical characteristics, and therefore have different advantages and disadvantages. For example, plastic Baby WASH play-yards are lightweight, collapsible, and easily moved at a caregiver's convenience. The colorful plastic play-yards are also visually appealing to caregivers and—as they are delivered by an outside source—easier to setup than a community-built play-yard. Plastic play-yards also have disadvantages, as the cost of the plastic play-yards is prohibitive to subsistence farming families and there is no roof to protect IYC from the elements of sun and rain. Furthermore, the lightweight nature of the plastic Baby WASH play-yards can be a drawback if larger toddlers and older playmates want to climb on or move the play-yard.

By contrast, the community-built Baby WASH play-yard is made from local materials to make it more sustainable and affordable. Time must be allocated to building the community play-yard, and the fixed structure in the household yard does not afford caregivers the option of using the play-yard in other contexts. Despite the immobility of the community-built play-yard, the roof protects IYC from the sun and rain and provides a more solid structure for IYC and playmates.

Although this pilot study conducted household-level intervention, the community-built play-yard allows villages to build communal Baby WASH play-yards in shared spaces that are accessible by multiple caregivers. Research is needed to understand how multiple caregivers and IYC might use a Baby WASH play-yard in tandem. The community-built play-yard may be a more feasible and practical option than an imported plastic play-yard for rural subsistence farming households to prevent fecal-oral transmission in IYC.

Family and community reactions to the Baby WASH play-yard. There was a strong cooperation between the health center staff and traditional leadership throughout the research process and building of the Baby WASH play-yards. Support at the overarching community level appeared to be present as the village headman in each village oversaw and approved of the construction of the community play-yards, and the construction required neighbors' help. This community support for the WASH interventions is also likely reflective of the presence of community-led total sanitation programs in Zambia's Eastern Province. Approximately one-third of rural Zambians are estimated to have access to improved sanitation, which stands in contrast to the high rates of latrine access in this study's participating families.³⁹

Caregivers in both groups reported that their immediate family was supportive of the play-yards. Although some caregivers reported positive feedback from neighbors, a number of caregivers reported negative reactions from community members. Concerns of neighbors' jealousy have been reported in other WASH interventions and appear to be salient in Baby WASH contexts as well.^{40,41} Education efforts must extend to community members, as play-yards are visible fixtures in the village environment and community rejection of the play-yards could be a threat to both the scale-up and sustainability of the intervention. Community reaction to the play-yard also highlighted the lack of immediate and visible benefits of either type of play-yard. If the results from using a play-yard intervention are not visible and the community and household do not see the benefit, this lack of visibility could be a key barrier that needs to be addressed in further developing this kind of intervention. Future research should address the community reaction of Baby WASH play-yard interventions to better understand facilitators and barriers from a community perspective.

Construction and upkeep of the Baby WASH play-yard.

Constructing the community play-yard and cleaning either play-yard adds chores in addition to helping women conduct their household chores. Traditional women's tasks, such as building the mud walls, painting the structure, or thatching the roof, contributed to logistical challenges that were not present with the plastic play-yards. The type of mud-brick construction used in the community play-yard structure is used throughout rural households in Zambia and has been noted both as durable and prone to water damage from heavy rains.⁴² Thus, the material of the community play-yard could impact durability of the structure over time and require seasonal upkeep. Moreover, daily upkeep of the play-yard—such as sweeping, keeping poultry out of the play-yard, and cleaning the mat—is a necessary component to prevent microbial ingestion. However, increasing women's household and field work can have direct consequences on the households' nutrition levels and childcare.⁴³ Rural women spend long hours farming, caring for children, cooking, and maintaining the household in a “zero-sum game” of time commitments.^{44,45} Undue burdens on rural women's time can reduce the use and efficacy of the intervention if maintenance becomes overwhelming. Future interventions must take into account the added demand of work and the balance of daily and seasonal upkeep that the Baby WASH play-yard intervention introduces. The time costs and savings of Baby WASH play-yards are a future area of research that represents a significant issue to the sustainability of the intervention.

The Baby WASH play-yard is a novel physical, social, and cultural environment for IYC. This study highlights the need to examine the changing dynamics of interaction between caregiver-IYC, sibling-IYC, and caregiver-community member as Baby WASH play-yards are introduced. Infant and young children in rural Zambia experience a novel social, cultural, and physical environment inside either type of play-yard. Caregivers acknowledged this changed social environment, both in how the IYC acts outside of the play-yard and the change of IYC's access to older playmates inside the play-yard, but did not express concern about the social environment. Longer observational studies and more in-depth interviews on IYC's social environment in this context would help elucidate if it is a barrier to sustained use. Whereas IYC aged less than

6 months are often constrained as they are carried around by their caregivers, placing IYC aged more than 6 months in an enclosed space is a cultural shift for rural Zambian households. The shift in cultural norms was captured by other caregivers' reactions to the intervention—both negative and positive—and could represent a further barrier to use if community acceptability is not an integrated part of the Baby WASH play-yard intervention package. Future Baby WASH play-yard interventions could benefit from providing caregivers with examples of how to entertain IYC in a safe, hygienic manner using household objects such as clean cups to help caregivers manage the tension between keeping IYC safe from possible fecal–oral contact and keeping IYC entertained in the play-yard.

In addition to changing social interactions, changes in the caregiving–IYC relationships could change responsive feeding practices.⁴⁶ To our knowledge, intensive studies of caregiver–IYC interaction in Zambia or contexts of rural, sub-Saharan African communities do not exist. Future research on Baby WASH play-yard interventions should include a more nuanced characterization of the IYC social environment in this setting. Dyadic social interactions between IYC and their caregivers (and peers) are critical aspects of healthy child development, especially domains of social–emotional functioning.⁴⁷ The play-yard provides an intervention in which the fields of child development, nutrition, and WASH coalesce and requires methods and metrics that fit the integrated nature of the intervention.

Safety concerns. To our knowledge, there are no guidelines on how long to use manufactured or constructed play-yards in terms of the maximum time per use, number of uses per day, or average time of use per day. This study discouraged multiple hours of use by encouraging the use of play-yard only when the caregiver was doing household chores for small amounts of time and could not be as vigilantly monitoring the infant to prevent geophagy. Over the course of the pilot study, the number of times and overall amount of time the play-yards were used increased in 24-hour recall reports. This increase could be due to caregivers using the play-yard more over time, caregivers becoming better at reporting usage in the second 24-hour recall, or caregivers feeling pressure to report more usage of the play-yard to researchers in the second 24-hour recall. This study also emphasizes the need for repeated counseling on safety practices for caregivers to best use this new object in their environment. Extended periods of use, whereas potentially helpful for caregivers, could be detrimental to IYC social and physical development.

Limitations. Our findings should be interpreted accounting for certain limitations of our study. First, the study is limited by conducting the pilot study with 21 households. A large-scale pilot study with more participating households would be ideal to examine how behaviors and attitudes about the community Baby WASH play-yard changed over time for caregivers and households. A longitudinal cohort design with a larger sample size would also allow a deeper examination of how IYC of different ages first react to the Baby WASH play-yard and how their use and reaction to the Baby WASH play-yard change as the children age. This pilot study is meant to test the feasibility and acceptability of a potential Baby WASH play-yard intervention with a small number of participants. Thus, this pilot study is not designed to draw population-level inferences and instead seeks to provide guidance on how other studies could integrate and test this type of intervention.

A second limitation is the lack of direct community member reaction to the Baby WASH play-yard and mat. Although this study asks households how their neighbors have reacted to the Baby WASH play-yard, conducting focus group interviews or key community informant interviews could characterize community acceptance more fully; however, this was not possible in our study.

A third limitation is the seasonality of this study. The pilot study was conducted during Zambia's dry season between May and October, during which there is little rainfall and the humidity is low. Because the study observed play-yard use during the dry season, it cannot fully characterize a household's use of the play-yard throughout the rainy season. The rainy season's wet conditions might make outdoor play-yards impractical because of heavy rains or colder temperatures when families more often stay inside the home. As the community-built play-yard cannot be moved into the field, this study is unable to comment on how caregivers would protect their IYC during agricultural production times. Seasonality, as it impacts Baby WASH-specific practices, is still a new and understudied area of research.

A fourth limitation is the reliance on self-report interviews and 24-hour recalls of play-yard use, without extensive observations of how caregivers and IYC use the play-yard. For instance, some caregivers reported using the play-yard while fetching water, which would bring the caregiver away from the play-yard and make it impossible for that caregiver to physically fetch water and also supervise the infant. Although most caregivers reported that the child was supervised by an adult during these use sessions—which could have included another caregiver, grandparent, or older child—there are limitations with self-report, and researchers were unable to observe these use episodes. These possible discrepancies highlight the need for more detailed observations than this pilot study can provide to better understand interactions between the caregiver–child dyad and safety considerations when implementing this kind of intervention. A related limitation is the Hawthorne effect, as it is possible that caregivers changed their Baby WASH-related behaviors because of the presence of an observer. Nevertheless, our results highlight barriers and facilitators to using a community-built Baby WASH play-yard design process and intervention to prevent IYC from ingesting microbes in the household environment.

CONCLUSION

Realizing the benefits of integrated WASH and nutrition interventions requires new or modified WASH strategies that are tailored to the fecal–oral transmission routes of IYC. The Baby WASH play-yard intervention is intended as part of a range of integrated strategies designed to address WASH issues rather than as a stand-alone solution. This study suggests that outdoor community-built Baby WASH play-yards to protect IYC from the risk of geophagy in the household yard have the potential to be both feasible and acceptable to households in rural Zambia in lieu of plastic play-yards. This study brings to light dimensions of social interaction through both the community's reaction toward the play-yards and the impact of the play-yard on the IYC social environment. This community-built play-yard could benefit future Baby WASH interventions by providing a locally constructed tool for households to reduce the risk of fecal–oral contamination in critical periods of early childhood.

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