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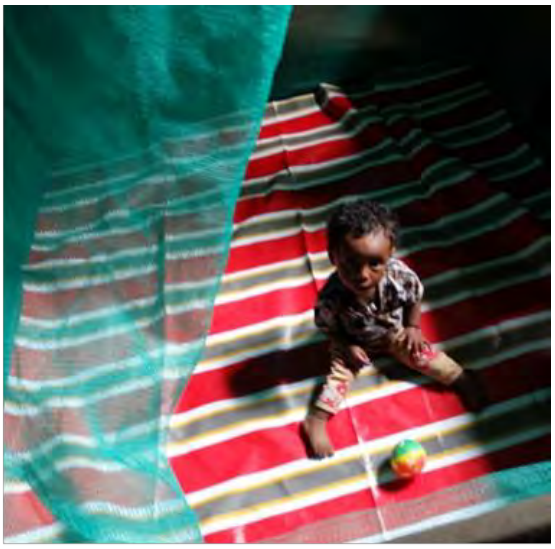

EXPLORING THE USE OF PLAYPENS AS A FEASIBLE OPTION FOR PROTECTING INFANTS FROM EXPOSURE TO ANIMALS, FECES, AND DIRT IN AMHARA, ETHIOPIA

APRIL 2020

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ACRONYMS

CFU	Colony-Forming Unit
CLTS	Community-Led Total Sanitation
CLTSH	Community-Led Total Sanitation and Hygiene
CPSC	Consumer Product Safety Commission (U.S.)
CSA	Central Statistical Agency (Ethiopia)
DHS	Demographic and Health Survey
E. coli	*Escherichia coli*
EED	Environmental Enteric Dysfunction
ENGINE	Empowering New Generations to Improve Nutrition and Economic Opportunities
GDP	Gross Domestic Product
HAP	Household Air Pollution
HEW	Health Extension Worker
IYC	Infants and Young Children
MIS	Management Information System
NGO	Nongovernmental Organization
OD	Open Defecation
ODF	Open-Defecation Free
PET	Polyethylene Terephthalate
PI	Principal Investigator
RCT	Randomized Controlled Trials
SCF	Save the Children Foundation
SHINE	Sanitation Hygiene Infant Nutrition Efficacy
SPSS	Statistical Package for Social Sciences
TIPS	Trials of Improved Practice
UCD	User-Centered Design
USAID	United States Agency for International Development
USD	United States Dollar
WASH	Water, Sanitation, and Hygiene
WASHPaLS	Water, Sanitation, and Hygiene Partnerships and Learning for Sustainability

EXECUTIVE SUMMARY

Background. For decades, public health interventions focused on breaking the fecal-oral transmission pathways driving extensive morbidity and mortality. However, by focusing largely on human feces, public health researchers and practitioners may have underestimated a key source of pathogens (Penakalapati et al., 2017). Mounting evidence suggests that animal feces ingestion is responsible for significant disease burden and growth faltering in infants and young children (IYC). The literature also points to exploratory mouthing of contaminated objects and direct ingestion of animal feces and soil playing a larger role in transmitting disease to IYC than previously recognized (USAID, 2018; Kwong et al., 2019; Penakalapati et al., 2017; Shivoga and Moturi, 2009).

Given these under-emphasized sources and pathways of infection, traditional water, sanitation, and health (WASH) interventions may not adequately block infant exposure to pathogens found in animal feces through exploratory mouthing and soil consumption (geophagy) (Pickering et al., 2019). The study described in this report explores the potential for a protective play space (or playpen) to help caregivers create a "safe zone" that reduces children's exposure to fecal pathogens, both animal and human, through exploratory mouthing and geophagy.

Objectives. Playmat and playpen interventions may be intuitively promising, but whether caregivers will consider them feasible and appealing for household use and will consistently and correctly use them are unknown. To this end, the USAID Water, Sanitation, and Hygiene Partnerships and Learning for Sustainability (WASHPaLS) Project, in collaboration with USAID/Ethiopia, the Amhara (Ethiopia) Public Health Institute, Plan International/Ethiopia, and the USAID Transform WASH Project, conducted behavioral research to determine if it is feasible and appealing[1] for rural households to consistently and safely use and maintain a protective playpen for IYC. We assessed feasibility and appeal by providing a playpen along with some behavior change motivation to households and documented use and maintenance, perceived benefits, obstacles to use and maintenance, family and community reactions, and preferred playpen attributes that facilitated use.

Methods. We conducted this research among 31 randomly selected households with an infant 7 to 12 months of age and a caregiver 18 years or older. Researchers purposively selected households across 10 selected villages (*gotts)* in two wards (*kebeles)* in Bahir Dar Zuria District of Amhara, Ethiopia. We employed a suite of non-experimental, mixed methods, including household trials of three distinct playpen designs over a three-week period, semi-structured interviews, structured direct observations, testing playpens and household floors for *E. coli*, and a rudimentary consumer valuation exercise (in the form of a buy-back offer). Central to the approach, known as Trials of Improved Practices (TIPS), is the consultation with target households to develop and test possible behavioral improvements, often involving the testing and refinement of enabling products,[2] such as a playpen. The TIPS method is built around sequential visits to the same households over a period of time—in this instance, three visits over three weeks—to assess the feasibility of, compliance with, and reactions to a proposed practice and product after their novelty has faded and households experience them in a routine context. Four group discussions immediately following the TIPS visits brought together study-participant families to compare all playpen models and discuss options for protecting their infants from animal-sourced pathogens and infant-specific pathways of exposure.

[1] We assessed playpen design appeal by considering qualitative and quantitative TIPS data and observations, coupling self-reported and revealed assessments of the utility and benefits from using the product, balanced by costs, consequences and challenges reported and revealed. Feasibility was similarly assessed, analyzing self-reported barriers and use, analyzed alongside usage and cleaning data and observations.

[2] An "enabling product" is one that facilitates a behavior, specifically serving as a behavioral determinant of the performance or non-performance of a target behavior.

We collected data from the various complementary methods concurrently, analyzed them separately, and finally interpreted and reported the results together to address research objectives and key themes.

We introduced three affordable playpen models to assess how particular features contributed to use and appeal. Researchers identified one such playpen (Model A) through Alibaba.com, the world's largest online marketplace. We also convened a user-centered design (UCD) workshop with farmer parents (falling in our target demographic) to co-design model playpens from locally available materials. We further refined these for safety and structural integrity, and then fabricated them for household testing as Models B and C. Researchers tested Models A and B in 10 households each, and Model C in 11.

Figure E-1: Models of Playpen Tested

Model A, an imported playpen, is lightweight, easily disassembled and portable, with five net sides and one nylon side panel with a zipper-closed door.

Model B, a locally designed playpen, is 1.5-meter square with 3 net and 1 canvas side w/door (opened with an extra-large button/string wrap closure), and removable net canopy.

Model C, a locally designed playpen, is a 1.5 x 1.1meter rectangle with 2 net sides and 2 spinning bottle walls for child stimulation, and 2 cm foam padding.

SUMMARY OF FINDINGS

Playpen Appeal. Playpens appealed to most caregivers and other household members. When asked about the experience of using a playpen for three weeks, all but one of the caregivers said the playpen was "really good." The caregivers appreciated the physical playpens, as well as the benefits associated with their use.

Caregivers (all birth mothers of the infants) recognized a range of benefits from using a playpen, including hygiene and health benefits to the infant, support of key motor skills development, as well as physical and mental benefits for the mothers. Mothers described the playpens as providing them relief from worry and a physical break from

Figure E-2: Benefits of playpen use, for infant and caregiver, as reported by caregiver at final visit

having to carry the infants on their backs. Some referred to the playpen as "*like having a family member*" to watch the child. Many mothers reported that having a playpen made childcare easier and let them attend to other chores. Caregivers reported their infants stayed cleaner and reported them putting less dirt and feces in their mouths. They said the playpens kept the infant from harm, including wandering off or getting burned by a cooking fire.

MOTHERS REPORT BENEFITS

"The pen protects the baby from harm. It helps me to do and finish activities within short time because doing any activity carrying the baby takes a longer time than doing it while placing the baby in the play pen."

"[The baby] doesn't move here and there and take chicken poop and other dirt."

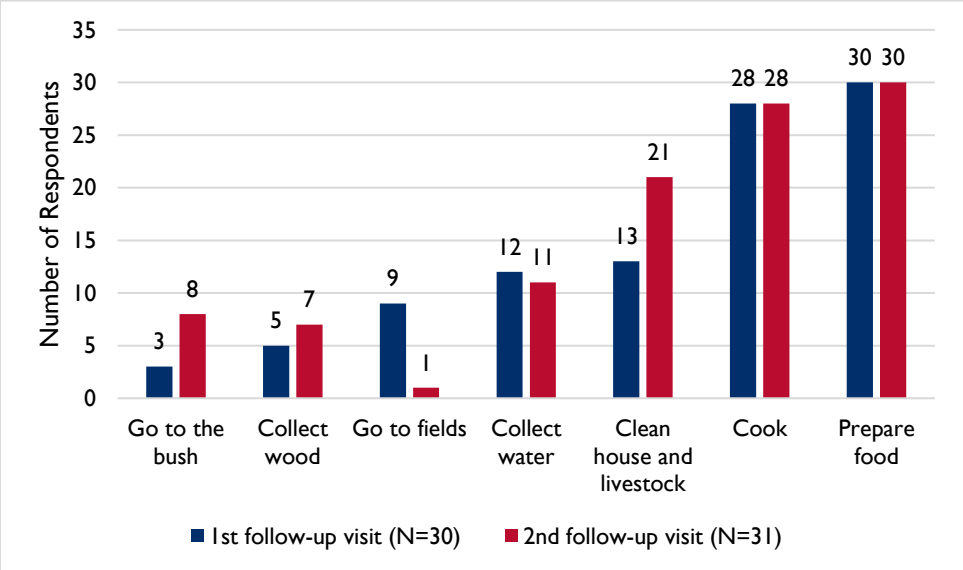
"We got … relief since we received the playpen."

Suggestions offered to improve the playpen designs included a more portable assembly to allow for use indoors and out (including in the farm fields), a mosquito/fly net for the two models without netting, a soft mattress and an absorbent liner, in addition to the playmat, to soak up urine and provide warmth.

Broader appeal. Our results indicate that local leadership, neighbors and visitors found both the playpen itself and the concept of creating a safe zone for IYC acceptable and appealing. Community members expressed that the infants and households were fortunate to be selected for the study and a desire to access such an innovation.

Playpen Use. We measured playpen use with 24-hour recall surveys with mothers during two follow-up visits after playpen distribution. All mothers except one reported using the playpen on the days before each visit, for an average of 134 minutes per day at the first follow-up visit and 123 minutes at the second follow-up visit.

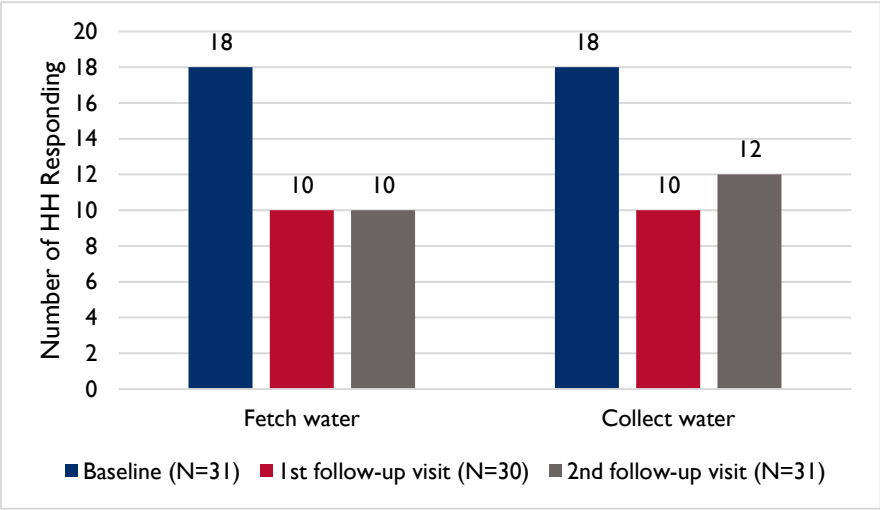
Figure E-3: Occasions mothers reported finding a playpen most useful by visit



When asked when the playpens were most useful, mothers reported during food preparation and cooking (which they expressed as two separate tasks), collecting water, and cleaning the house and livestock corrals. Mothers reported using the playpens to complete different types of work at consistent rates between the visits, with two exceptions: 1) nine mothers mentioned using the playpen while going to the fields at the first follow-up visit and only one said this at the second follow-up visit (most likely because the second follow-up visit took place during the planting season when most family members were in the fields so brought the infant along); and 2) mothers mentioned using the playpen to facilitate house and corral cleaning more often at the second follow-up visit. We documented that mothers were less likely to bring their infants with them to fetch water and collect wood if they had a playpen. Daughters (and, less often, sons) were increasingly left to watch the infants while the mothers were carrying out these tasks.

Playpen Cleaning. The team instructed household members to wash the playpens and mats at least every three days, or whenever they looked visibly soiled. At both follow-up visits, we asked mothers how they cleaned and maintained the playpen "*since the last visit*" (over the past 7-14 days). The majority of caregivers (74% during the second follow-up visit) reported that they washed the mat, and 58% reported that they scrubbed the whole playpen.

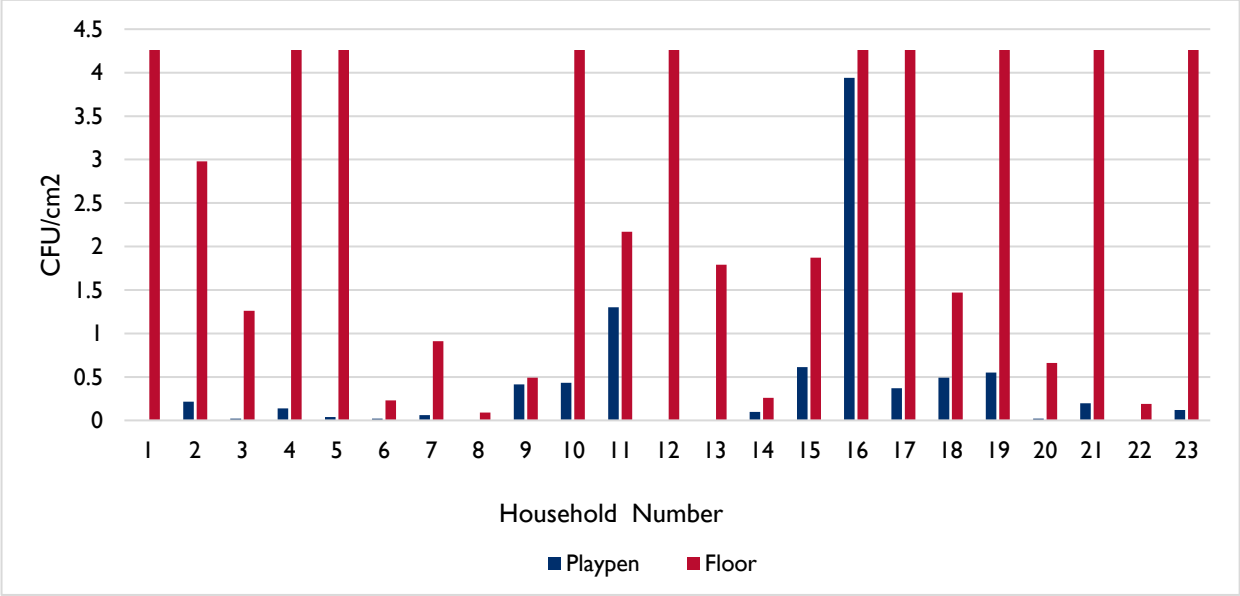
Figure E-4: Infant accompanying household member during task, by visit



Many households (40%, at the first follow-up visit and 60%, during the second visit) reported cleaning their playpens only when they looked dirty. At the first follow-up visit, 30% of the respondents reported cleaning daily. During the second visit, nine respondents (30%) reported cleaning their playpens "a few times," three (10%) said they cleaned them more than once a day, three (10%) said they cleaned the playpens a few times, and no one reported daily cleaning.

Playpen Microbial Sampling. During the final visit, the team took swab samples at 23 study households for *E. coli* analysis, as an indicator of microbial contamination of the playpen surface compared to other surfaces. The team took two swabs in each household: one from the living room floor and a composite swab of the playmat and the playpen rim.

Figure E-5: E. coli Counts, by Density and Location



E. coli was detected in 18 of 23 playpen/playmat composite samples tested after 3 weeks in study households, but at densities far below those of floors sampled in the same household. Six playpens were contaminated at counts below 0.1 CFU/cm^2, and all but 2 of the 23 playpens were <1.0 CFU/cm^2. By

comparison, 10 of 23 sampled floors were contaminated at the maximum detection limit of 4.26 CFU/cm^2. (For reference, the Model C area totals 22,500 cm^2, and the Model B area is 16,500 cm^2. We detected no relationship between type of playpen and the contamination levels of the playpens.

Valuation assessment/Buy-back offer. Researchers told study participants at enrollment that the study was for a few weeks, and that when they returned the playpen at the end of the study, they would receive a small gift of appreciation. When the team completed household data collection, we offered participants a choice between keeping the playpen or receiving a payment of 500 Ethiopian birr (about USD 17),[3] our best estimate of a viable consumer price for a locally assembled or mass-imported playpen. All caregivers opted to keep the playpen over accepting a cash payout.

DISCUSSION/CONCLUSIONS

The study found that playpens were appealing and were used daily by all but one of 31 study households. Respondents perceived an array of benefits, and all chose to keep the playpens rather than accept cash equivalent to a price point we believe to be potentially viable for a scaled-up commercial playpen enterprise.

Caregivers reported keeping vulnerable young children in the playpens for about two hours per day. We did not assess how much time those children spent on dirt floors on a given day. We also note that we examined only the short-term (three to four weeks) use, acceptability, and appeal of the playpens.

We cannot determine whether the time the children spent on the comparatively cleaner surfaces of the playpens resulted in a sufficiently lower exposure to pathogens to result in any measurable health or growth benefit. Families allowed poultry on and inside the playpens, as well as multiple older children with visibly soiled feet and clothing. It is reasonable to expect the playpens to continue to be soiled and their protection against pathogen exposure limited by how clean the families are able to keep them. Based on the results of this study, playpens alone cannot plausibly provide protection to IYC from environmental contamination. Promotion of playpen use would certainly need to be part of a more comprehensive effort to maintain a hygienic environment.

We are confident that access to the enabling technology of a playpen, together with promoting a safe zone, bolstered self-efficacy.[4] Playpen users reported an intention to reduce infant mouthing and consumption of fecally contaminated objects; in group discussions at the close of the study, the majority of participants endorsed playpens as an effective strategy for maintaining a safe zone and keeping their infants from mouthing contaminated objects. In both household interviews and group discussions, participants repeated their commitment to use the playpen to prevent children from eating dirt and feces, as well as to keep them safe from other harm. However, despite these public commitments and enhanced self-efficacy, we observed many risky practices that could expose IYC to feces in households. Whether the limited time in playpens will mitigate the impact of these practices is uncertain.

We identified a number of other perceived benefits of playpen use for caregivers, IYC, and siblings that are noteworthy. These additional benefits include reduced burden on women, with possible impact on mental health, reduced burden on young girl caretakers, as well as other possible health benefits, such as reduced exposure to cooking emissions that are linked to childhood pneumonia, childhood stunting, and related impaired cognitive development of IYC. These results support further exploration of the potential benefits and commercial viability of scaling up use of playpens in rural, agricultural households as part of a comprehensive approach to IYC development and women's empowerment.

[3] Ethiopia is one of the poorest countries in the world, with an annual gross domestic product (GDP) of USD 783, according to the World Bank (2019).

[4] We rely on the definition of "perceived self-efficacy" offered by Bandura (1994): a person's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives.

1. BACKGROUND AND PURPOSE

1.1 BACKGROUND

Chronic malnutrition in infants and young children (IYC), characterized by growth stunting or low height for age, has short- and long-term consequences for health, cognitive and motor development, learning capacity, productivity, wages, and reproductive health (UNICEF, WHO, and World Bank, 2012). Growth stunting is pervasive in low- and middle-income countries, affecting as many as 165 million children under five (UNICEF, WHO and World Bank, 2012). Cummings and Cairncross (2016) documented the multifactorial and intertwined biological, social and environmental causes of stunting. The pervasiveness of stunting despite decades of nutrition and water, sanitation, and hygiene (WASH) interventions spurred a reexamination of WASH-related disease transmission pathways (Cummings and Cairncross, 2016).

For nearly six decades, the seminal "F-diagram" (Wagner and Lanoix, 1958) was used to depict routes of pathogen transmission from human feces to a new host via fluids, fields (floors, earth, dirt), flies, fingers, fomites (surfaces/objects) and food. The traditional F-diagram focuses exclusively on human excreta, tracing the transmission of pathogens that are ingested through different exposure routes onto hands and into water and food. Public health measures addressed these transmission routes by constructing barriers to transmission through improved WASH interventions (USAID, 2018).

A 2018 USAID/WASHPaLS desk review synthesized the latest understanding of key pathways of fecal microbe ingestion by IYC and the links to diarrhea, environmental enteric dysfunction (EED) and poor nutrition and development outcomes. The central finding of this review is that two under-emphasized aspects of the F-diagram are worthy of increased attention: 1) domestic animal excreta as an important reservoir of disease-causing agents in the environment, and 2) exposure of IYC to pathogens via ingestion of dirt (geophagy) or human and animal excreta, as well as exploratory mouthing behaviors (USAID, 2018).

1.2 STATEMENT OF THE PROBLEM

Animal feces are likely to constitute an important source of zoonotic pathogens to the home environment in low-income countries, particularly in rural areas (Delahoy et al., 2018). Several studies have documented significant sources of animal fecal contamination in the domestic environment, including ruminants in urban Bangladesh (Harris et al., 2016), rural Ethiopia (Headey and Hirvonen, 2016), Zimbabwe (Ngure et al., 2013), Zambia (Reid, 2018), and peri-urban Peru (Marquis et al., 1990). Overnight corralling of poultry or livestock within the same room as IYC is also associated with elevated markers of EED (George et al., 2015) and stunting (Marquis et al., 1990; George et al., 2015).

Direct ingestion of fecally contaminated soil and/or animal feces is a critical pathway for IYC exposure to pathogens and is common in low-income environments (Marquis et al., 1990; George et al., 2015; Shivoga and Moturi, 2009). IYC ingest dirt and feces through mouthing soiled fingers, play objects and household items (Marquis et al., 1990; George et al., 2015; Shivoga and Moturi, 2009) as well as through exploratory ingestion of contaminated soil and/or poultry feces. Soil ingestion among IYC is associated with increased risk of diarrhea (Shivoga and Moturi, 2009), elevated markers of EED and stunting (George et al., 2015).

As evidence of this less recognized pathogen source grows, so does documentation of previously underemphasized transmission pathways, such as IYC exploratory mouthing. Findings from three large-

scale randomized controlled trials (RCTs) show traditional WASH[5] had no impact on child growth (Null et al., 2018; Luby et al., 2018; Humphrey et al., 2019). Taken together, they suggest that attention to previously underestimated sources and pathways of infection is merited to better understand their influence on child health and growth.

The efficacy, adoption, constraints, and scale-up potential of measures such as playmats and playpens, improved flooring, modified animal husbandry and other approaches for reducing IYC exposure to fecal pathogens are yet to be systematically explored or documented.

In light of the paucity of research on this topic, some WASH projects are implementing activities intended to improve child growth and health without having a clear understanding of the behavioral and biological plausibility of their protective effects against fecal contaminant risk. To fill this gap in the evidence, the USAID WASHPaLS Project, in collaboration with USAID/Ethiopia, the Amhara (Ethiopia) Public Health Institute, Plan International/Ethiopia and the USAID Transform WASH Project, conducted behavioral research to determine the feasibility and acceptability of establishing a protective, hygienic "safe zone" via a playpen for IYC.

[5] One of the RCTs, the SHINE Trial in Zimbabwe, included a playpen component and began to address the animal source/mouthing vector. Results are still emerging; the playpen did reduce exploratory mouthing but did not affect overall health or growth (Humphrey et al., 2019).

2. RESEARCH OBJECTIVES

2.1 GENERAL OBJECTIVE

The purpose of this research was to determine whether consistent and safe use of playpens is feasible in rural households. We also sought to assess end-user enthusiasm for the playpens and conduct a rudimentary analysis of their economic valuation.

2.2 SPECIFIC OBJECTIVES

- Assess caregiver use of playpens to separate infants from animals, dirt and feces.
- Explore the feasibility and appeal of using and cleaning playpens.
- Identify playpen attributes affecting use, appeal, and perceived value.
- Assess the broader concept of maintaining a safe zone for infants.
- Gain a better understanding of the financial value of playpens to end-users.
- Document current practices related to child exposure to animals, feces, and dirt.

3. STUDY DESIGN AND METHODOLOGY

We conducted a Trial of Improved Practices (TIPS), consisting of:

1) Three-week household trials of three different playpen models;
2) Structured and semi-structured interviews with caregivers;
3) Structured direct observations of animals in the household compound, feces in specific areas of the compound, and mother's response to infant mouthing of objects;
4) Microbial testing of surfaces; and
5) A valuation "buy-back offer" of playpens.

We recruited 31 households to participate, which allowed us to test each model in 10 households (and one model in 11 households). In addition, a subsample of the TIPS participants and their families took part in group discussions. At least one member of all households participated in these group discussions.

As part of this TIPS process, we sought to simulate typical government and/or nongovernmental organization (NGO) health promotion outreach, introducing the concept of risk from uncontrolled infants wandering and mouthing, and to solicit a commitment from mothers and fathers to create and maintain a safe space for infants. The study aimed to determine if and how the *behaviors* of creating and maintaining a safe zone (and limiting free movement of the infant) allowed the caregiver to better monitor, clean and control the objects within the infant's reach.

The team instructed mothers to practice four specific behaviors to establish and maintain a safe zone:

- Place the infant in the playpen instead of on the dirt.
- Sweep the perimeter around the playpen daily.
- Intervene when the child puts dirt, dung, or dirty-looking objects in his/her mouth.
- Wash the playmat whenever it looks visibly dirty, and at least every three days.

The playpen products we tested exhibited a range of attributes (varying sizes, with and without a door or mosquito netting, etc.).

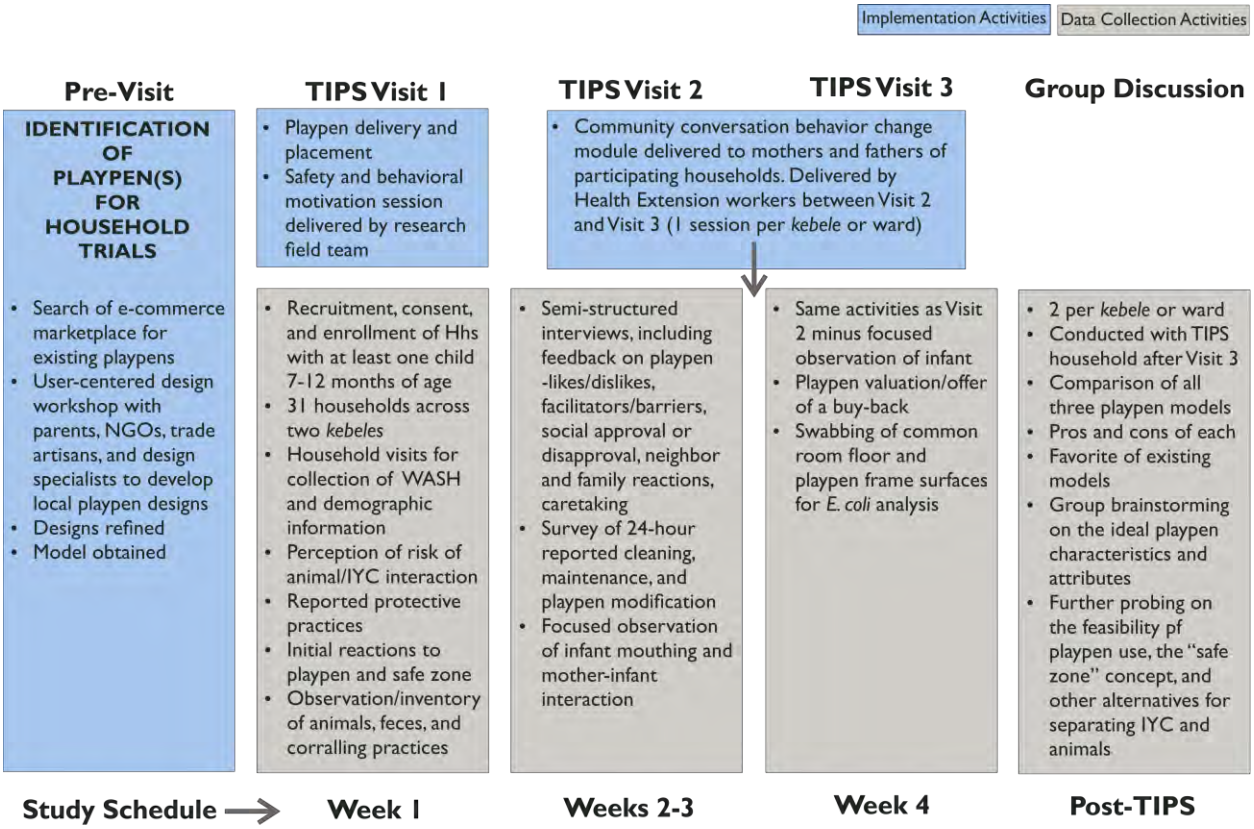
We collected data from the various TIPS activity elements concurrently, analyzed them separately, and finally interpreted and reported them together. Table 1 outlines the measures and methods used to address each of the study objectives, and Figure 1 provides an overview of the study activities and methods.

Table 1: Study objectives, outcomes, measures and methods

Objective	Measure(s)	Method(s)
1. Assess caregiver use of the playpens.	– Frequency and timing of use – Adherence to rules (specifically related to safety) – Reasons for use – Changes in caregiver behavior	24-hour recall by respondent, direct observation and semi-structured interviews by survey personnel
2. Explore feasibility and appeal of using and cleaning playpens	– Perceived benefits and barriers to using and cleaning playpens – Reported method and frequency of cleaning – Type and frequency of other maintenance – *E. coli* on surfaces	– Semi-structured interviews and observation – Swabbing of playpen, playmat and floor of common room for *E. coli* testing
3. Identify playpen attributes affecting use, appeal and perceived value	– Household members' identified preferences and perceptions of various playpen features (e.g., portability, insect netting, shape and padding) – Participant comparison of all playpen models and attributes	– Semi-structured interviews and valuation/buy-back component – Group discussions

Objective	Measure(s)	Method(s)
4. Assess the broader concept of maintaining a safe zone for infants	– Reported use and cleaning – Reported practice of other safe zone behaviors (sweeping, intervening when mouthing)	– 24-hour recall, direct observation and semi-structured interviews – Group discussions
5. Gain a better understanding of the financial value of playpens to end-users	– Number of households who opted to keep the playpen over a cash buy-back of USD 17.	Valuation/buy-back component at close of final visit
6. Document practices related to child exposure to animals, feces and dirt	– Inventory of animals and feces – Range and frequency of corralling and feces management practices – Caregiver intervention against mouthing	Semi-structured interviews and observation

Figure 1: Study components/activities, methods and content addressed at each of the three visits



3.1 PLAYPEN SELECTION AND DEVELOPMENT

To identify playpens for testing, we first looked for appropriate existing products that could be purchased by members of resource-poor, rural households, should research conclude playpen use to be feasible, appealing, and provide a measure of protection against pathogens. Our search within Ethiopia yielded only a few expensive, imported "Pack and Play" options marketed to elite, urban consumers. Concurrently, WASHPaLS conducted an online search of potential playpen products meeting U.S. Consumer Safety Standards[6] (Ethiopia has no safety standards for playpens) and potentially available for

[6] U.S. federal law requires that what we refer to as "playpens" comply with the play yard standard with additional requirements, including those of the Consumer Product Safety Improvement Act of 2008 (CPSIA). The standard is published in the Code of Federal Regulations

import for USD 20. We judged this price ceiling as the highest price that local households would be willing and able to pay, with possible installment options or partial subsidy considered, following consultation with the USAID Transform WASH Project, other key informants and findings from a previous willingness-to-pay exercise conducted by the USAID Empowering New Generations to Improve Nutrition and Economic Opportunities (ENGINE) Project (USAID, 2015). We identified a playpen model manufactured in China and distributed as the North States brand as potentially importable to Ethiopia for an anticipated bulk import price of USD 16, inclusive of shipping, import duties and taxes. We subsequently purchased the North States playpen to serve as one of the three playpen models used in the study.

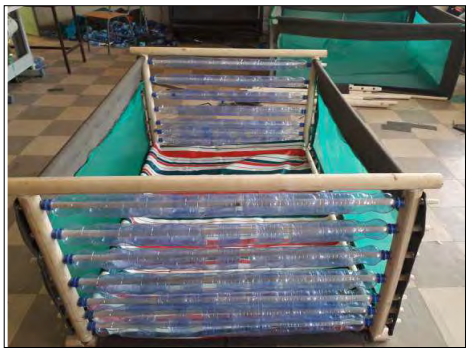
In addition to the imported North States product, we co-designed and sourced playpens of our own for household consumer testing, via a partnership with the USAID Transform WASH Project. We relied on a user-centered design (UCD) approach, bringing together rural agrarian parents, Health Extension Workers (HEWs) from the Ethiopian government's maternal and child health program and staff from the Ethiopian Regional (Amhara) Polytechnic College. The research team introduced UCD workshop participants to the problem, familiarized them with international safety standards and child development considerations, and challenged them to participate in an iterative design process using locally available materials and reflecting local user preferences. Two playpen models emerged for testing along with the imported North States model. The Amhara Polytechnic College, under contract with WASHPaLS, produced 12 units of each of the two playpens designed through the workshop. More detailed descriptions of each model are provided in Annex A; Annex B contains the UCD workshop report.

International and local design and child-development specialists confirmed that all three playpen designs met U.S. Consumer Safety Standards for play yards. Local experts inspected and certified the playpens as safe after manufacturing.

Figure 2: Models of Playpens Tested

Model A, an imported playpen, is lightweight, easily disassembled and portable, with five net sides and one nylon side with a zipper door.

Model B, a locally designed playpen, is 1.5 meters square with 3 net sides, 1 canvas side with button-closure door, and a removable net canopy top.



Model C, a locally designed playpen, is a 1.5 x 1.1m rectangle with bottle walls for child stimulation and 2 cm foam padding.

3.2 TRIALS OF IMPROVED PRACTICE

Designing by Dialogue (Dickin et al, 1997) first documented the TIPS method and it was further adapted for a range of health technical areas (Rosenbaum et al., 2015). It employs in-depth household observations and semi-structured questionnaires to develop and test possible behavioral improvements, including such behavior-enabling products as a playpen. The first academic paper featuring a TIPS effort focusing on safe play spaces in rural Africa was recently published (Reid et al., 2018). TIPS actively

at 16 CFR Part 1221. The standard incorporates by reference ASTM F406-13, which contains the specific requirements and descriptions of the tests for play yards. Manufacturers and importers of play yards must certify in a Children's Product Certificate that the play yards comply with the standard and the additional requirements after the play yards were tested for compliance at a CPSC-accepted, third-party laboratory.

engages target users in developing solutions that are contextually and culturally appropriate, and always involves sequential consultations over time with the same informant/consultants to assess feasibility, compliance, modifications and reactions to proposed new practices and products once the novelty has faded and households are experiencing them in the context of their daily routines.

Our TIPS protocol incorporated a versatile elicitation method designed and validated to assess barriers to and facilitators of a given behavior under study (Middlestadt et al., 1996) using straightforward, simple and disarming questions, such as:

- *What are the good things about using the playpen?*
- *What's not so good about using/cleaning the playpen?*
- *What makes it difficult to use the playpen? What makes it difficult to clean the playpen?*
- *What would make the playpen easier to use/clean?*
- *Who approves or disapproves of you using time and resources to clean the playpen?*
- *Have neighbors seen the playpen? What kinds of comments and questions do they have?*

These kinds of questions, which offer respondents the opportunity to suggest modifications to improve the product itself as well as its use, are intended to illuminate a wide range of behavioral determinants (such as perceived consequences, perception of risk, self-efficacy and social norms, among others).

3.3 GROUP DISCUSSIONS

A few days following the third TIPS visit, we invited study households to a group discussion where all three playpen models were prominently displayed and discussed. The team asked participants to compare and discuss the pros and cons of each, reflecting on their three weeks using a particular model in light of the other options. Discussion group facilitators also asked participants to express their preference among the existing models and to brainstorm on the ideal playpen attributes. Facilitators consulted participants on the feasibility of using a playpen to facilitate separating children from dirt and feces and the playpen's usefulness in helping to create a safe zone. Finally, the team asked participants for other ideas to protect infants as either a complement to or substitute for playpens.

3.4 SAFETY AND BEHAVIOR MOTIVATION SESSIONS

To motivate the new behavior and assure safe use, we conducted a single combined playpen safety behavior change promotion session at each *household* at Visit 1, when the playpen was first introduced. Between the second and third TIPS visits, HEWs who were well-known and active in the study villages conducted a *community-level* behavior change session to reinforce improved practices and encourage social support for playpen use and infant–animal separation. The team collected no data from these sessions.

These sessions built on motivational material first developed as part of the Sanitation Hygiene Infant Nutrition Efficacy (SHINE) trial in Zimbabwe and further adapted for the Essential WASH Actions training package.[7] The hypothesis of change underlying the materials assumes that product use and maintenance are most influenced by the following behavioral determinants:

- Increasing perception of risk (of exposure to animals and feces),
- Self-efficacy and skills to create a safe zone for IYC,
- Access to an "enabling product" (the playpen), and
- A supportive social environment.

[7] https://www.fsnnetwork.org/essential-wash-actions-training-and-reference-pack-supplement-essential-nutrition-actions

In the initial household-level behavior change session, we proposed specific behaviors to caregivers. At the close of the session, caregivers, and their husbands (if present) signed a certificate with the following public commitments:

- *We will put the baby in the playpen instead of on the dirt floor.*
- *We will watch our baby and take action if he/she starts to put dirt, chicken poo or other dirty-looking things into his/her mouth.*[8]
- *We will wash the playmat and anything else we put in the playpen with flowing water and soap every three days, or whenever they look dirty.*
- *We will sweep the safe zone daily of any human or animal feces, so baby can't eat it.*

Researchers emphasizes safety, specifying that the child should never be left unattended and that the playpen would never be placed within two meters of an open fire, on a raised surface, or near strings or cords. The team left a second safety reminder sheet with household members, and encouraged caregivers to hang both the safety reminder and the Certificate of Commitment on the wall of the sitting room where the playpen was to serve as a reminder and to "nudge" (or unconsciously prompt) practicing safe zone principles and safety behaviors. (See Figure 3, for English-language translations of the Amharic materials). Although caregivers' literacy levels were low, the ceremonious act of both parents signing the certificate (after field interviewers verbally reviewed all content) served as an overt commitment of intention. Mothers and field interviewers together hung both documents on a prominent wall of the house as a reminder of that commitment. The target behaviors as well as safe usage were reviewed with mothers at each visit.

Figure 3: Translations of certificates of commitment and safety information flyer in each household

HEWs conducted the group session with support from Plan International/Ethiopia, following the Community Conversation model (Born, 2008) used by the government health extension program. The existing module from the Essential WASH Actions Training Package was pretested and further adapted to closely follow the standard practice of the HEWs. WASHPaLS staff trained the HEWs for this purpose (see Section 3.6 for description of the study team). HEWs convened the session between the second and third household visits.

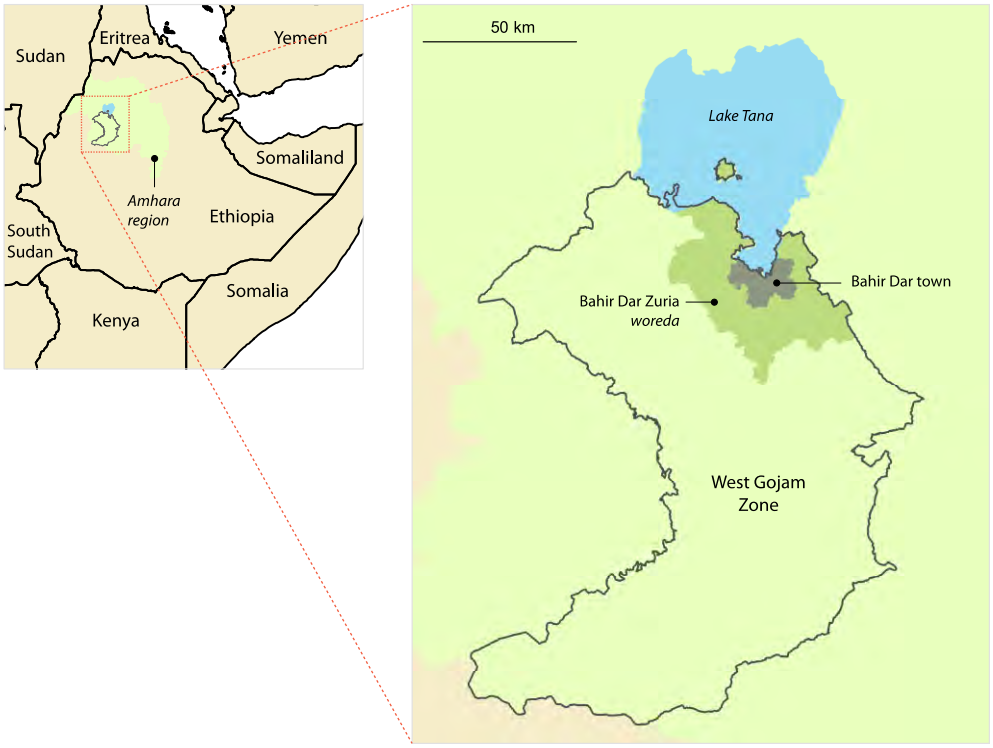
[8] Previous work demonstrated that caregivers were aware of potentially harmful infant mouthing but did not take action, which spurred us to incorporate this specific action.

3.5 SITE SELECTION AND SAMPLING

USAID WASHPaLS identified Ethiopia as a sensible research setting because it offered the potential to collaborate with a USAID-funded integrated WASH and nutrition activity as well as meeting other general criteria: a rural, agricultural population dependent on animal husbandry; high rates of child stunting[9]; interest in addressing health issues related to child–animal interaction; and supportive government policies, such as a commitment to "total sanitation and hygiene." Ethiopia, and the Amhara Region in particular, was an early pioneer in the testing, deployment and local adaptation of Community-led Total Sanitation (CLTS—locally termed CLTSH, with the addition of the term "Hygiene").

We recruited 31 households with infants 7 to 12 months of age in *Debranta* and *Feriswoga,* two *kebeles*[10] of Bahir Dar Zuria *woreda*[11] *in* West Gojam Zone of the Amhara Region of Ethiopia (see Figure 4). We purposely selected the region, *woreda*, *kebeles* and *gotts*[12] (village clusters) in consultation with USAID, collaborating partners and government authorities. Each household received one of the three playpen designs.

Figure 4: Study area: Bahir Dar Zuria woreda, West Gojam Zone; Amhara Region, Ethiopia



Because PSI (through the USAID-funded Transform WASH project) and Plan International/Ethiopia were implementing WASH and nutrition projects in Amhara, we were able to leverage their presence to execute this research. Plan International/Ethiopia facilitated introductions to local government officials, HEWs, community leaders and households with children in our target age range.

We selected villages using the following eligibility criteria:

[9] The most recent 2018 UNICEF/Government of Ethiopia Ministry of Women and Children Affairs Fact Sheet reports stunting in Amhara District to be 46.3%, the highest of the stunting rates of all regions in the country, which range from 14.6% to 46.3%.

[10] *Kebele* = ward or neighborhood, consisting of at least 500 families, or about 3,500 to 4,000 persons.

[11] *Woredas* are subdistricts. While the exact number fluctuates with administrative re-organization, Amhara Region has about 150 subdistricts.

[12] *Gott* = village cluster, usually comprised of 60-90 households.

- High-to-medium access to water, as classified by routine government management information systems (MIS) and the Demographic and Health Survey (DHS) (to assure the possibility of cleaning the playpen);
- Declared "open defecation-free" (ODF) within the past three years, as tracked by the government MIS (to minimize human feces in the environment); and
- Less than 0.5 km or 30-minute walk from a passable roadway (to facilitate placement of bulky playpens and subsequent interviewer access).

The first two criteria are regularly tracked by government information systems (USAID, 2019). In addition, the DHS assesses water access (Central Statistical Agency [Ethiopia] and ICF, 2016).

We then randomly selected households within the 10 villages via the following protocol: HEW supervisors working with Plan International/Ethiopia accessed their rosters of routinely collected household information to identify eligible households with infants 7 to 12 months of age and a mother who was at least 18 years old. HEWs prepared a complete, numbered listing of all households in each village meeting these two criteria, and we randomly selected six households (if that many met the age criteria), for a total of 55 households across the 10 villages. We then travelled with local guides (identified by the local government to assist the study team) to each of the villages and screened households, in randomly selected order, for the following additional eligibility criteria:

- Engaging in subsistence agriculture;
- Possessing at least three poultry and at least one cow, goat or sheep; and
- Living within a 30-minute walk from a passable road.

3.5.1 RECRUITMENT INTO TIPS

Local guides, together with local leaders accompanied our study personnel to locate the study households randomly selected from the Plan International/Ethiopia list. If a caregiver was not at home at the time of the recruitment visit and was not located within 20 minutes, we proceeded to the next household on the list. For sampled households where the caregiver was not at home, we tried to obtain information about the household to ascertain if it met all study criteria. If the household met the criteria, we attempted through family and neighbors to inform the caregiver of our return date.

The team briefed the members of the first three households on the list that met the criteria about the study objectives and procedures and invited those households to join the study. In one village, we could not identify a third eligible household with a 7- to 12-month-old infant, so the team recruited a third household from a neighboring village. In another village, which had recently experienced a poultry plague, we identified only two eligible households that owned three chickens, so we recruited one household that recently lost a dozen chickens and planned to restock "soon." The team inadvertently recruited a fourth household in one village; as it met all our eligibility criteria, we decided to retain it, in the event that a household dropped out over the course of the study. In the end, all households remained in the sample throughout all three visits, hence our total of 31 study households. All households invited to participate agreed to do so.

After obtaining caregiver consent and completing the interview component of the first visit, we assembled one of the three playpen models in the interior common room of each house. The first household recruited in each village received playpen Model C, the next household received Model B and the third household received Model A. The team tested Models A and B in 10 households and Model C in 11 households. A washable ball was distributed with each playpen model in to interest the infant in the playpen. Each study household participated in the three home visits described in Figure 1.

We focused on children between 7 and 12 months because international child development specialists recommend the introduction of playpens starting at 4 to 6 months, when infants can roll over, grasp a toy, and lift their heads (Personal communication, Bethe Almeras, FHI360, 4/4/2018; CDC, 2018). In Ethiopia, mothers tend to keep young infants on their backs for the early months.

By six months, most babies are able to sit up and reach for items and are independent enough to feel secure if a caregiver is still in sight (CDC, 2018). Our study design originally included infants from ages 6 to 10 months, but pretesting showed some six-month-old infants still had difficulty sitting independently, so the team increased the minimum age to participate in the study to seven months.

International guidance permits the use of a playpen until children reach 34 inches or 30 pounds and up to 24 months of age (Safety Standard for Play Yards, 2019). However, by 10 months most infants (though less than 34 inches or 30 pounds) start to crawl and pull themselves up, and by 12 months many are standing and starting to walk (CDC, 2018). Each of the three playpen models we tested can accommodate a child pulling on any part to facilitate standing without the playpen tipping. A playpen is still safe after a young child has started walking. However, as a child becomes more mobile, he is often more difficult to contain in a playpen without toys or other companions.

3.5.2 RECRUITMENT INTO GROUP DISCUSSIONS

The research team recruited 42 members from study households to participate in four group discussions, two held in each *kebele*. We selected participants purposively. The research team identified and subsequently invited household members who were particularly articulate, critical or otherwise vocal about the playpen, childcare and animal care. At least one member of all households participated in the groups—either the mother/caregiver, her husband or an adult relative—and no two relatives took part in the same group discussion. Travel, participant availability and other logistical considerations also influenced participation.

3.5.3 SELECTING HOUSEHOLDS FOR MICROBIAL SAMPLING

Our original protocol called for microbial sampling of playpens, playmats and the common room floors in all study households, but shortages of analytical supplies in-country at the time of our work necessitated the selection of a sub-sample of 23 of our 31 households for testing, with two swabs per household. We eliminated the most distant village in both *kebeles* (three households each) and randomly selected one additional household in each *kebele* for exclusion.

3.6 DATA COLLECTION

Fieldwork took place in June and July of 2019. The WASHPaLS team managed all field logistics through the FHI 360 Ethiopia country team and its regional office in the Amharan regional capital of Bahir Dar.

3.6.1 TRAINING AND SUPERVISION

The team elected four experienced interviewers through a competitive application and interview process and trained them in study procedures for four days. Two rounds of survey instrument pre-testing, conducted in concert with enumerator training in households outside Addis Ababa, informed several modifications to the survey instruments, including phrasing of questions, additions to the possible response categories and correction of skip patterns. The field practice also highlighted areas requiring additional training and orientation. One of the four interviewers, who had extensive supervisory experience from previous field studies, served as field supervisor. One or the other principal investigators (PIs) was present at the field sites for almost all the field work. Seven community guides,

appointed by the local *gott* administrations, helped the field team carry playpen materials and identify the randomly selected households in their villages.

3.6.2 TIPS AND GROUP DISCUSSIONS

Four interviewers made three home visits for the TIPS data collection. Two of the four managed the group discussion sessions, while the other two took detailed notes. The team used different methods to collect a range of data, as illustrated in Table 1 and Figure 1.

The interviewers collected data from the semi-structured interviews and observations with Android tablets using the SurveyCTO platform (SurveyCTO, 2019). They also took hand-written notes to capture responses not readily or fully covered by the pre-coded response categories and to record data on other themes highlighted in the training. The team reviewed these handwritten notes, coded and entered them using the tablet-based questionnaire codes and/or into MS-Word templates to capture detailed descriptions and brief verbatim quotes from respondents.

Within a few days of completing the third visit in each *kebele*, the interviewers convened the group discussions at the *kebele* health centers and displayed all three playpen models. The interviewers facilitated guided discussions to explore drivers and barriers to use of the playpens as well as recommendations for improvement and identification of ideal characteristics. The facilitator, notetakers and the bilingual PI, who was present for all group discussions, reviewed detailed notes from each group discussion, taken in English, immediately afterward. Group discussions took approximately 90 minutes, with added time for introductions and breaks.

3.6.3 MICROBIAL TESTING

The team swabbed the playpen rims and playmat, along with other surfaces on which IYC are routinely placed, for *E. coli* during the third visit of the TIPS study. They took two swabs in each of a subsample of 23 households: one of the common room floors, and another composite swab of the playmat and the playpen rim.

Precut templates demarcated the swabbing areas. Researchers swabbed the floor 1.5 meters from the doorway and within (potential) crawling reach of the infant. The playmat swab was taken from the center of the mat, and then the other side of the same swab was used to sample the playpen rim. The rim sample for playpen Models A and B was from above the playpen door; Model C was swabbed on the side of the rim expected to have the most hand "traffic."

The team used a commercially available environmental sponge sampling kit, the EnviroMax Plus 6" Sterile Round Foam Swab & Collection Tube, which is pre-moistened with half neutralizing buffer and half 0.1% Peptone water. After swabbing, researchers returned the sponges aseptically to the tube, sealed the tubes and transported them in a thermal cool-box for microbiological analysis.

To prepare for *E. coli* analysis, researchers rinsed each swab, and collected the wash water for analysis in accordance with a procedure developed by the Emory University Center for Global Safe Water, Sanitation and Hygiene for use by the Amhara Public Health Institute Regional Laboratory. The steps for this process included adding seven ml of sterile water to the swab container, placing the swab back into the tube, screwing the lid down well, vortexing the tube for 30 seconds, incubating it for five minutes at room temperature, vortexing for another 30 seconds, opening the swab container and pouring the swab elute into an empty 15 ml conical tube. The researcher repeated these steps, and then pressed the swab against the side of the tube to squeeze out as much remaining wash solution as possible before the final wash solution was transferred to the 15 ml conical tube. Finally, a sample of the solution was placed on Emerald Scientific/ Hardy Diagnostic Compact Dry EC Trays, incubated and analyzed for *E. coli*.

We did not swab household surfaces at baseline nor at the second visit; however, the team thoroughly cleaned all playpens and mats at baseline with 55% alcohol wipes after assembly and placement in households, to minimize possible external *E. coli* contamination through manufacture, transport, storage and assembly.

3.7 DATA PROCESSING AND ANALYSIS

The team trained interviewers to code participant responses to open-ended questions directly into the corresponding set of pretested response categories. Interviewers coded any responses to the open-ended questions or categorization of observations that they could not clearly code into those categories as "other" in as much detail as possible for subsequent coding.

The team reviewed "other" responses including both questions and observations noted in the SurveyCTO in team meetings and entered them into pre-coded response categories where possible. If a response did not fall squarely into a previously established code, it was coded as "other" for later analysis. The two co-PIs independently coded these "other" responses, together with the "other" responses noted in the meeting writeups. The co-PIs created several new codes for responses that did not fit in the existing response categories, and left some responses not frequent enough to merit a new category as "'other." We sought to minimize the uncoded responses.

Following quality control/quality assurance checks for missing/inconsistent values and outliers, we conducted basic descriptive statistics using Statistical Package for Social Sciences (SPSS) and Microsoft Excel and disaggregated data over time (Visits 1, 2 and 3) and by different playpen models (A, B and C).

Interviewers first documented qualitative information collected during TIPS interviews in handwritten notes subsequently transferred to Microsoft Word. The co-PIs independently coded the qualitative data and then compared their analysis for inter-coder reliability. The PIs used a thematic Excel matrix to code the interview notes and reported that data with quantitative data to address the research objectives and key themes.

The discussion facilitator, the notetaker and one of the PIs reviewed the extensive notes from group discussions immediately following the session (see Section 3.6.1). The team did not record group discussions; therefore, they were not transcribed. The facilitator and the PIs further reviewed discussion notes were and confirmed thematic codes.

3.8 MICROBIAL TESTING

We did not swab household surfaces at baseline or at Visit 2. However, all playpens and mats were thoroughly cleaned with 55% alcohol wipes after initial assembly and placement in households, to minimize possible external *E. coli* contamination through manufacture, transport, storage, and assembly. During TIPS Visit 3, we swabbed playpen rims, playmats, and common room floors for *E. coli.* Two swabs were taken in each of our subsample of 23 households. The first was one of the common room floors (taken 1.5 meters from the doorway, in an area where infants were likely to crawl as part of their daily routines. The second was a composite swab of the playmat (taken in the center of the mat) and the playpen rim (sampled above the playpen door for playpen Models A and B; Model C was swabbed on the side of the rim expected to have the most hand "traffic"). The composite was achieved by using each side of a single swab for the mat and playpen rim, respectively.

Pre-cut templates demarcated the swabbing areas. Swabs were collected using a commercially available environmental sponge sampling kit, the EnviroMax Plus 6" Sterile Round Foam Swab & Collection Tube, which is a pre-moistened single swab with half neutralizing buffer and half 0.1% Peptone water. After the

swabbing, the sponges were returned aseptically to the tube. Tubes were sealed and transported in a thermal cool-box to the regional laboratory in the town of Bahir Dar for microbiological analysis.

In the laboratory, we processed each sample as follows: 1) remove the sponge from the tube using sterile forceps; 2) add 7 ml of sterile water into the tube; 3) place the sponge back into the tube and seal it; 4) vortex the tube for 30 seconds; 5) incubate the tube for five minutes at room temperature; 5) vortex the tube for another 30 seconds; and 6) re-open the tube and pour the swab eluent into an empty 15 ml conical vessel. Steps were repeated, and the swab was pressed against the side of the tube to squeeze out as much remaining eluent as possible before the final wash solution was transferred to the 15 ml conical tube. A 1 ml aliquot of the eluent was then transferred to a Contact Dry™ EC pre-sterilized plate containing culture medium and a cold water-soluble gelling agent (Hardy Diagnostics, Santa Maria, CA, USA), recapped, and incubated at 35 degrees Celsius for 24 hours, and then counted. We report results as colony-forming units (CFU) per cm^2 of surface swabbed, with maximum detection limit for this method at 4.26 CFU/cm^2 (corresponding to 200 CFU/ml on the plate).

4. FINDINGS

4.1 SOCIODEMOGRAPHIC AND ECONOMIC CHARACTERISTICS OF SURVEYED HOUSEHOLDS

This section presents social, economic and demographic characteristics of survey participants and their households. All 31 study respondents were the biological mothers (and primary caregivers) of the infants in the study, ranging in age from 20 to 37 years. The mean age of respondents was 27, with many (20 out of 31) falling under the age of 30 (Table 2).

Twenty-one of 31 caregivers reported never attending school. Eight of the mothers completed some elementary (primary) education (Grade 1-8), and only two attended any secondary school.

When asked about the highest grade completed by any member of the surveyed households, including the mother, four reported no schooling, but 22 of 31 said a household member completed some primary school. Only two households reported having at least one member with some secondary school education, and only one reported that a household member achieved a diploma (Table 2).

The average household size was five individuals, with a range of three to nine. Nine of 31 households had between four and six members.

Sixteen of the 31 interviewed households reported having only one child younger than five, and the remaining 15 of 31 had two children under five years of age. All respondents except one reported having one 7- to 12-month-old child, consistent with our eligibility criteria.

Most households depended on crop production for their livelihoods, with a few reporting both crop and livestock production as their major source of livelihood. One caregiver reported that a household member was a salaried government worker, but we still considered the household to meet the screening criterion of "engaging in subsistence agriculture" as they

Table 2: Caregiver and household characteristics

Caregiver characteristics	**(N=31)**
Characteristic	**% (n)**
Age	
20-24 years	33 (10)
25-29 years	33 (10)
30-34 years	26 (8)
35-39 years	9.7 (3)
Education Level	
Never in school	68 (21)
Primary (1-4)	13 (4)
Primary (5-8)	13 (4)
Secondary (9-12)	6.5 (2)
Household Characteristics % (n)	
Education Level (household)	
Never in school	13 (4)
Religious/adult education	6.5 (2)
Primary (1-4)	39 (12)
Primary (5-8)	32 (10)
Secondary (9-12)	6.5 (2)
Diploma	3.2 (1)
Household size	
1-3	19 (6)
4-6	61 (19)
7-9	19 (6)
>9	0
Household cash-generating activities*	
Sell crops	61 (19)
Sell animal products	39 (12)
Petty trade	23 (7)
Sell labor	13 (4)
Household possessions (as SES proxies)	
Cell phone	65 (20)
Electricity**	52 (16)
Functioning radio	23 (7)

** Total percentage adds up to greater than 100% as some respondents engage in multiple activities.*
*** One subdistrict containing five villages was electrified and the other not, reflected above. This was the only notable difference between the two subdistricts.*

lived fully immersed in the rural setting, raising poultry and using cow dung as fuel. Activities identified as producing cash for the households were selling crop products (19 of 31 households), animal products (12 of 31 households), petty trade (7 of 31 households) and labor (4 of 31 households).

Cell phone ownership among the surveyed households was relatively high (20 of 31 households), but access to a functional radio was low (7 of 31 households), with electrification the only distinguishing characteristic between the two study *kebeles:* one was highly electrified, and the other had little to no connection. We found no other notable differences between the wards.

4.2 WATER, SANITATION, AND HYGIENE ACCESS

As mentioned above, we purposively selected the two study *kebeles* for their ODF status. The team established this selection criterion to minimize uncontained human feces in the environment as a source of pathogen exposure. Medium-to-high access (or within 30 minutes round trip to fetch, as defined by the Federal Ministry of Water Resources) to water was also a criterion for *kebele* inclusion, because water access is essential for maintaining playpen hygiene. We sought to determine if lack of water access was a deterrent to maintenance. About half of study households (16) accessed an (improved) community well or borehole as their main source of water. Another four accessed a protected spring as their primary water source, bringing the total number of households accessing an improved water source to 20 of the 31 households in the sample. Eight accessed an unprotected spring (capped or otherwise), and the remaining three respondents used a standing pond or gully as their main source of water; 11 of the 31 households used unprotected water sources.

Table 3: Water, sanitation and hygiene access of study households

Variable	N	% (n)
Latrine Availability		
No	31	68 (21)
Yes	31	32 (10)
Latrine Condition		
Improved	0	10 (0)
Unimproved	10	90 (10)
Handwashing Station Availability		
No	10	70 (7)
Yes, within 3 meters	10	20 (2)
Yes, beyond 3 meters	10	10 (1)
Households' Main Water Source		
Community well/borehole	31	52 (16)
Unprotected spring	31	26 (8)
Protected spring	31	13 (4)
Standing pond/puddles/gullies	31	10 (3)
Well on premises	31	0.0
Households' Water Use		
Drinking	31	100 (31)
Cooking	31	100 (31)
Cleaning dishes	31	93 (29)
Cleaning house	31	81 (25)
Bathing	31	81 (25)

We also hypothesized that households in ODF-declared *kebeles* would be more likely to embrace measures to reduce contact with excreta. The teams documented no direct visible evidence of OD; still, despite the recent ODF certifications of the two *kebeles,* only 10 of 31 actually possessed a private latrine at the time of our visit (Table 3). The latrines that we observed were unimproved, basic pit latrines, with low evidence of usage. Only half of those appeared to be currently in use by the surveyed households. None met minimum standards of an improved pit latrine. One basic pit latrine, though not covered and thus not meeting definitions of an improved latrine, was well-maintained.

We also collected data on handwashing facilities. Only three of the 10 latrines had handwashing stations within an acceptable distance of the latrine, and only these three of the 31 total households had any sort of fixed handwashing station on the compound. Two of the ten latrines had a jerry can tippy tap

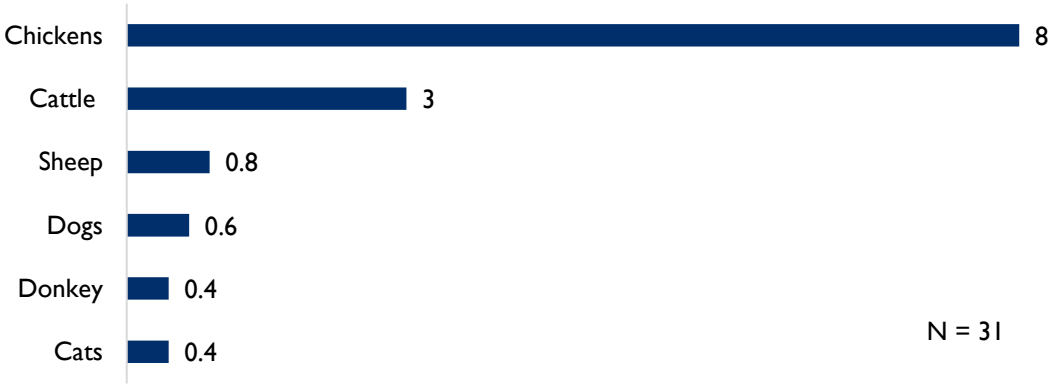
(handwashing station)[13] and one of them had a PET water bottle tippy tap. None of the handwashing stations had adequate handwashing materials (water, soap, ash).

4.3 ANIMAL HUSBANDRY PRACTICES AND RISK PERCEPTION OF ANIMAL-IYC INTERACTIONS

4.3.1 LIVESTOCK OWNERSHIP

Study criteria required that households possessed at least three chickens and a cow, sheep, or goat. Due to a recent chicken plague, one household in the sample did not currently have chickens. Figure 5 shows that households had on average eight chickens and three cattle.

Figure 5: Average number of animals per household



4.3.2 PERCEPTIONS ABOUT IYC INTERMINGLING WITH ANIMALS

Study households generally reported an awareness of the risks to small children and animals in close proximity. Sixty-five percent of respondents reported concerns about their children being trampled or harmed by animals, and 55% also noted that proximity with animals exposed IYC to risk of disease. Only two caregivers said they believed that children's contact with animals had no negative effects. Among the 17 who responded that children might be put at risk of disease, most associated IYC–animal contact with diarrhea, followed by common colds and abdominal pain. Qualitative data also included evidence that caregivers associate livestock with risk of child exposure to ticks, chiggers and other insects.

All study participants thought it was appropriate for children to be in close proximity with livestock at some age, though that age varied (Table 4). Over half (52%) believed the appropriate age was between 6 and 10, and 29% thought it should be above age 10.

Table 4: Households' perceptions regarding the minimum age to have children and animals mix

Response	Percent
From birth	0%
When child can walk, about 1 year old	3.2%
From 1 to 5 years	16%
6-10 years	52%
Greater than 10 years	29%

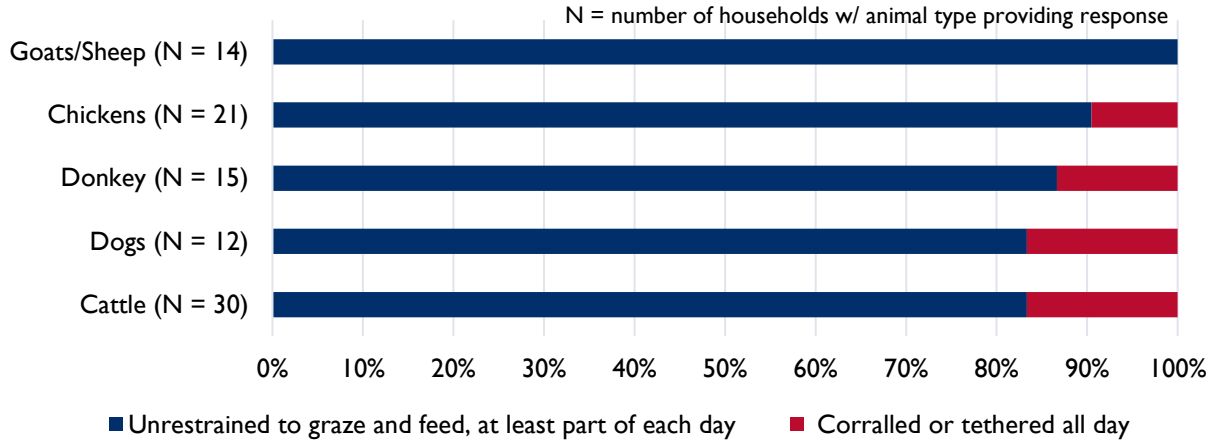
[13] A "tippy tap" is the name of a type of "do it yourself" handwashing station, most often constructed of recycled materials, including some sort of water receptacle (often a ½ or 1-liter PET water bottle, Jerry can or gourd) and often a hollow tube of some sort to direct and limit water flow. The original designs were connected to a string and foot pedal, which gave them the name Tippy Tap, because the string tipped the container and served as a running water tap.

4.3.3 HOUSEHOLDS' PRACTICE OF SEPARATING ANIMALS FROM HUMANS

Even though most caregivers believed children should not be in close proximity to animals until they are at least 6 to 10 years of age, the observed practice is quite different. In almost all study households, team members observed children ages 7 to 12 months, as well as other young children, in close proximity to or interacting with poultry, calves and cats. Infants were in close proximity to chickens in 22 of 31 households and to calves in 7 of 31 households. Small children were not permitted to be close to large cattle or donkeys, or to most dogs, which were generally aggressive watchdogs and/or herders as opposed to pets. Some caregivers expressed the belief that when children grow up close to animals, they become good shepherds and tenders of their animals as they get older.

Reported animal-corralling and grazing practices support that IYC have frequent contact with animals at an early age (Figure 6). Note that the unrestrained animals referred to in the figure are not necessarily in the household. In many instances, team members observed poultry, cats and cattle (mostly calves) unrestrained in study households, with cattle and poultry defecating at will and the waste left in place. Almost half of the households with cattle had at least one animal tethered at the time of the interview, but only five of the 30 households with cattle kept the cattle tethered all day, and only two households kept chickens cooped all day.

Figure 6: Percentage of households restraining or corralling livestock during the day



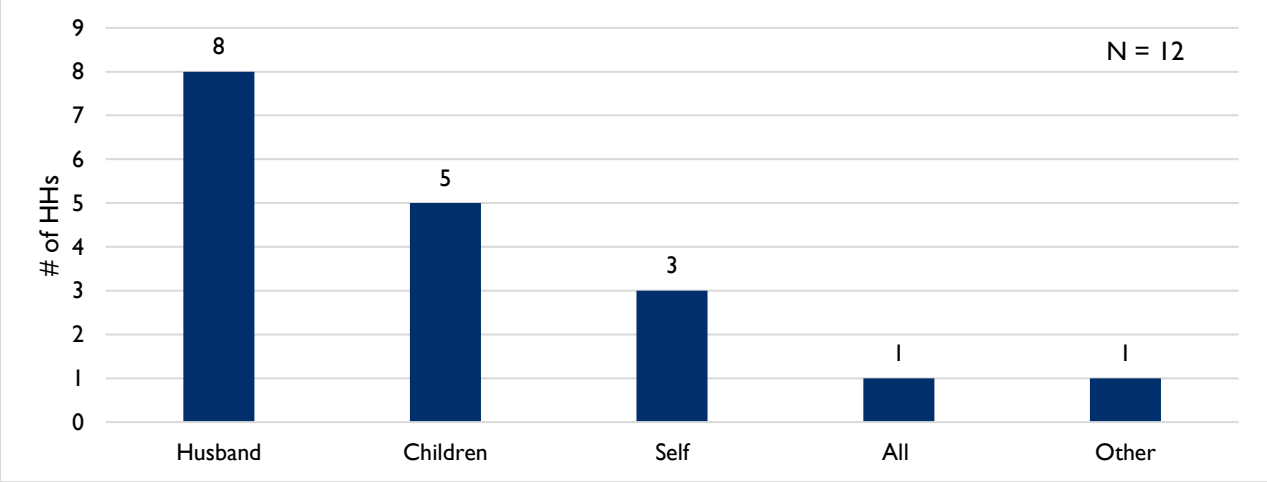
Nighttime exposure to animals and potentially to animal feces is even greater than potential daytime exposure. As shown in Table 5, the majority of households keep animals inside, with the exception of dogs. Families frequently bedded chickens in open coops (built-in clay cubbies); cattle, goats, sheep and donkeys had varied arrangements but were always restrained. Most cattle, half of the goats and sheep, many donkeys, and many chickens sleep at night in an inside corral that is separated from where the household members sleep. However, in many households, livestock sleep inside the family living quarters with no distinct separation from humans (almost 44% of households for poultry and 21% for goats or sheep), either unrestrained or in an inside corral with no distinct room separation. In almost all the cases, animals that sleep in an interior corral separated from the human sleeping area still use the same door as the people and cannot really be considered as separated from humans, because they linger and defecate in common areas as they are brought in and out of the corral. One household proudly showed interviewers the efficiency of bedding cattle in the kitchen, which allows manure to be easily collected and slapped on kitchen walls for drying and subsequent use as fuel. Many households had multiple indoor/outdoor arrangements depending on conditions, as reflected in Table 5.

Table 5: Animal nighttime sleeping arrangements

	In an outside corral	Tied outside w/ a rope but not further restrained	Outside unrestrained	Inside corral, separated from human sleeping	In an inside corral, no distinct room separation	Inside, unrestrained	N (multiple responses accepted)
Chickens	3%	0%	13%	40%	7%	37% (open nests)	30
Cattle	22%	0%	0%	83%	10%	0%	29
Goats/Sheep	29%	7%	0%	50%	21%	0%	14
Donkey	32%	0%	0%	69%	0%	0%	13
Dogs	36%	0%	46%	9%	0%	18%	11

Some caregivers (39%) reported that at least one member of their household spent the night with their animals (Figure 7). The caregivers' husband slept with the animals in 8 of the 12 households. Children (most often male children) and caregivers also spent the night with animals, cited by 5 and 3 of the 12 households, respectively.

Figure 7: Household member spending the night guarding animals



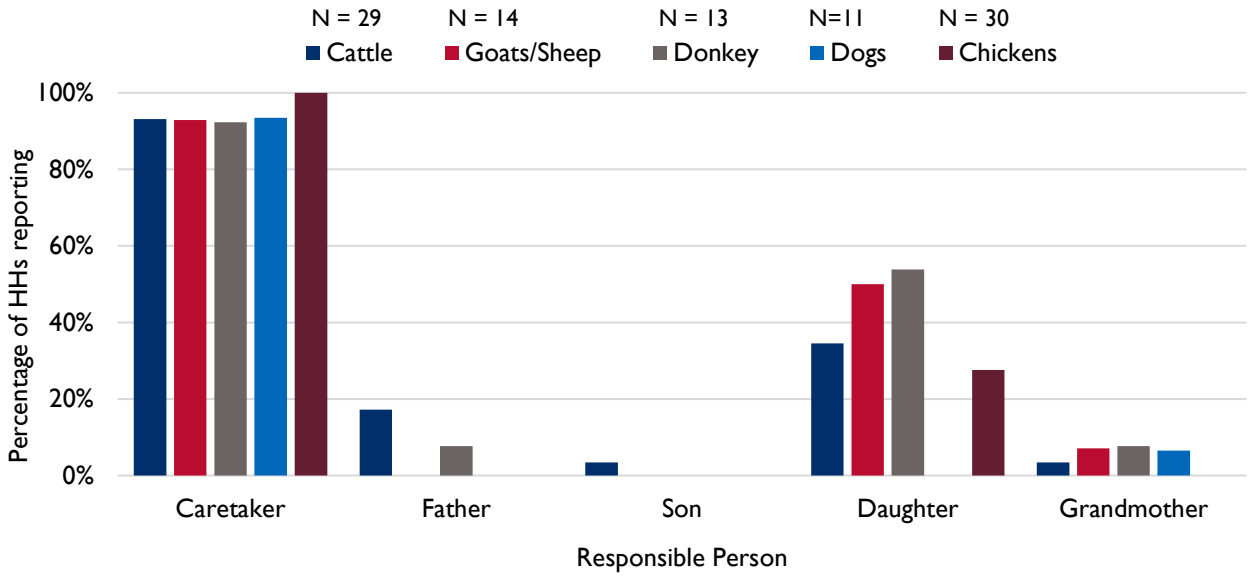
Households expressed concern over the risk of nighttime cattle theft, which influenced their nighttime behaviors. Interviewers witnessed two incidents of cattle theft during the four-week study period, attesting to the immediacy of this concern.

4.3.4 ANIMAL FECES IN COMPOUND: COLLECTION, MANAGEMENT AND USE

Direct contact with animal feces, regardless of whether for use or disposal, presents risk of pathogen exposure and has possible implications for infant and child health. This risk is further elevated by the observed absence of handwashing after handling feces and before food preparation. Figure 8 indicates household members responsible for collection of animal feces. Between 93% and 100% of the child caregivers, depending on the animal, reported that they bore primary responsibility for collecting animal feces.

These results suggest high exposure to animal feces and their pathogens among those most often caring for IYC, which may lead to increased pathogen exposure for IYC, given the low perceived risk reported and the lack of handwashing observed during household visits.

Figure 8: Household member responsible for collecting animal feces, by type of animal



In many instances, respondents reported using their bare hands to collect animal feces. When analyzed by type of animal, respondents usually collected ruminant feces such as cattle and goat/sheep feces using bare hands (79% and 71%, respectively) while they usually collected dog and chicken feces with plastic materials (64% and 62%, respectively). Respondents collected donkey feces with bare hands (46%) or plastic materials (46%).

All surveyed households used cow dung for fuel, and no household reported using any other excreta for fuel. All households reported using all forms of excreta for fertilizer. A single household reported disposing of dog feces in the bush or on the road.

Cow dung is also used as a construction material in houses and household structures, as well as to "clean'" house. Wiping dung over floor, seating and wall surfaces to compact dust and "freshen up" appeared to be a common practice. This practice was notably *not* mentioned in answers to open-ended questions about how feces are used, but we observed households using the cow dung for this purpose.

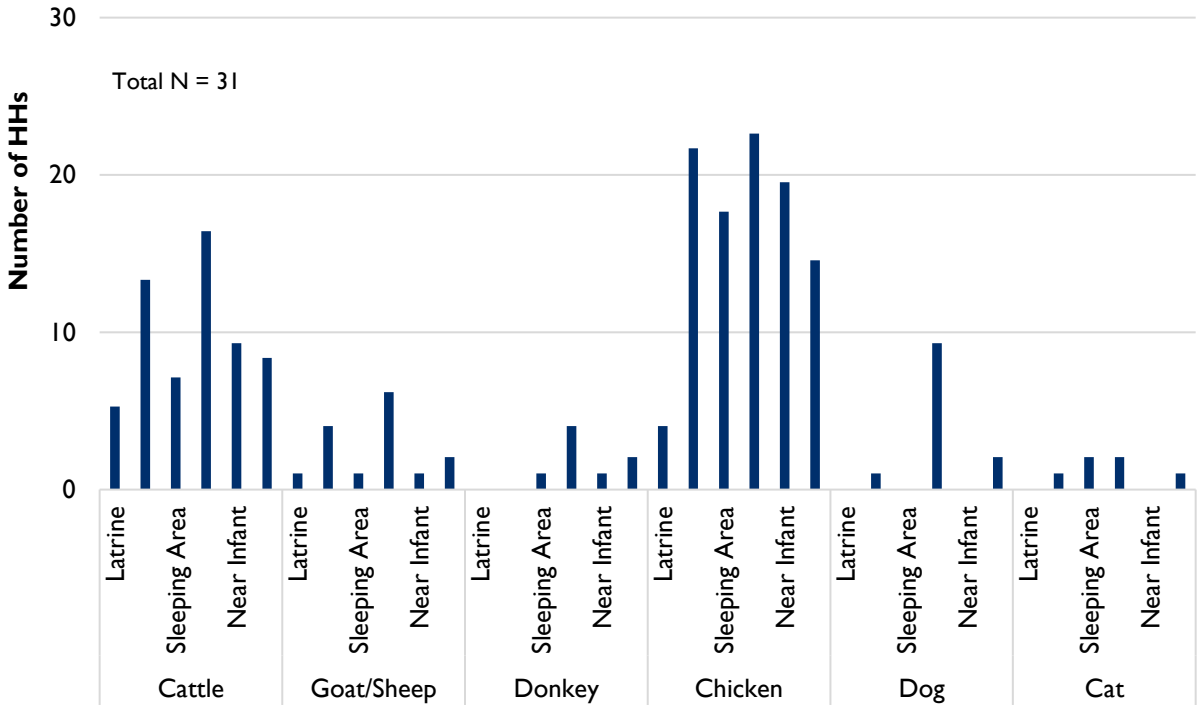
Table 6: Use or storage of feces, by type of animal

	Use Immediately (%)	Pile in courtyard or store for later use (%)	Total (N)
Cattle	42	58	26
Goat/Sheep	46	54	13
Donkey	54	45	11
Chickens	85	14	28

Eighty-five percent of households reported using chicken feces immediately, whereas about half of respondents said they used other types of animal feces immediately and stored the rest in a courtyard or other location for later use (Table 6). Interviewers observed visible feces inside and outside the home, noting the location of feces and the proximity of the infant to ambient feces. Despite the fact that chicken feces were regularly collected and used immediately for fertilizer, many households had chicken feces visible in the kitchen (22 of 31, or 70%), sleeping area (18 of 31, or 57%) and in close proximity to the infant at observation time (20 of 31, or 63%), as well as high quantities in the compound (23 of 31, or 73%). The team found cattle feces in the kitchen (13 of 31, or 43%) and the compound in many households (16 of 31, or 53%), which is not surprising given that cow dung is used for fuel and is commonly stored in piles in the household compound. About one-third of

households (30%) also had cattle feces in close proximity to the infants during interviews.[14] The team observed feces in all study households (Figure 9).

Figure 9: Animal feces observed in study households, by type and location



4.3.5 HOUSEHOLDS' CURRENT PRACTICES TO PROTECT IYC FROM ANIMALS, ANIMAL FECES, AND DIRT

One objective of the study was to better understand households' perception of risk regarding IYC's contact with animals, feces, and dirt and what if anything is done to protect infants. To this end, researchers asked caregivers a general, open-ended question about what measures they take to protect IYC from harm. Thirty of 31 respondents reported carrying infants on their backs, 27 of 31 (87%) reported closely watching IYC, 18 of 31 (53%) reported breastfeeding, and 15 of 31 (48%) reported keeping IYC away from fire (48%). Few mothers mentioned vaccination (5 of 31) or well-baby visits (2 of 31). No one mentioned separating children from animals, or anything related to environmental hygiene. Also notable given the religiosity of rural communities in Amhara and the number of infants wearing large crosses around their necks, no one mentioned prayers, crosses or God's will (Figure 10).

When asked specifically what they do to separate animals and young children (without specifying daytime or nighttime), caregivers most often reported separating the sleeping places of humans and animals (22 of 31, or 71%) and corralling animals at night (14 of 31, or 45%). These practices are promoted by the national maternal and child health program through HEWs as one of the 16 health actions of the Health Extension program. Just 5 of 31 (16%) of the households mentioned corralling or tethering animals outside during the day to separate animals and young children (Table 7).

[14] Note that these figures are based on total sample size, without calculating whether the household owned this particular animal; given that many animals were unconstrained and wandered to other households. Not owning a particular animal did not protect household compounds from the feces of that animal.

Figure 10: Number of caregivers reporting various practices to protect infants from harm

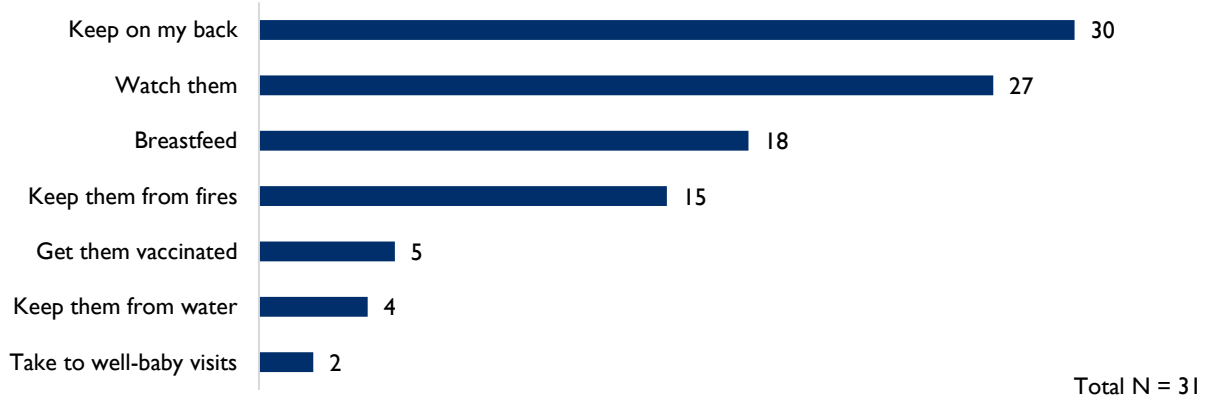


Table 7: How households usually separate animals and young children

	Total (N=31)
Separate sleeping places of humans and animals	22 (71%)
Corral them at night	14 (45%)
Corral/tether them outside during day	5 (16%)
Other	4 (13%)
***Totals add up to >31 (and >100%) as some respondents supplied more than one response.**	

4.4 APPEAL AND FEASIBILITY OF PLAYPEN USE AND MAINTENANCE

We documented time spent in playpens, caregiver and infant activities while the playpen is in use, perceived benefits and barriers to using and maintaining the playpens, and perceived approval or disapproval of playpen usage by other families and the broader communities, in order to assess perceptions of social norms as they affect use. In addition, the study documented perceived value through the valuation/buy-back offer. The team recorded most of the measures at both Visit 2 and Visit 3 to document changes over time as the novelty of the product playpen wore off.

4.4.1 HOUSEHOLDS' DAILY PLAYPEN USE

We asked caregivers about playpen use during the previous 24 hours at both Visits 2 and 3. Combining all three playpen models, the average reported amount of time that infants spent in a playpen was 134 minutes/day at Visit 2 (SD=100 min), and123 minutes/day at Visit 3 (SD=84 min). We cannot reject the null hypothesis that the reported usage was equal between visits ($t(60) = 0.45$, $p = 0.65$). Disaggregating by playpen model, the only instance of a difference between visits large enough to be compatible with rejection of the null hypothesis of no change was for Model B (Visit 2 mean = 188 min/day, SD = 146; Visit 3 mean = 87 min/day, SD = 54), where $t(11) = 2.05$, $p = 0.065$).

Figure 11: Mean reported time in playpen over past 24 hours, in minutes, by playpen model and visit.

Error bars are standard deviations, and sample sizes are noted within the columns.

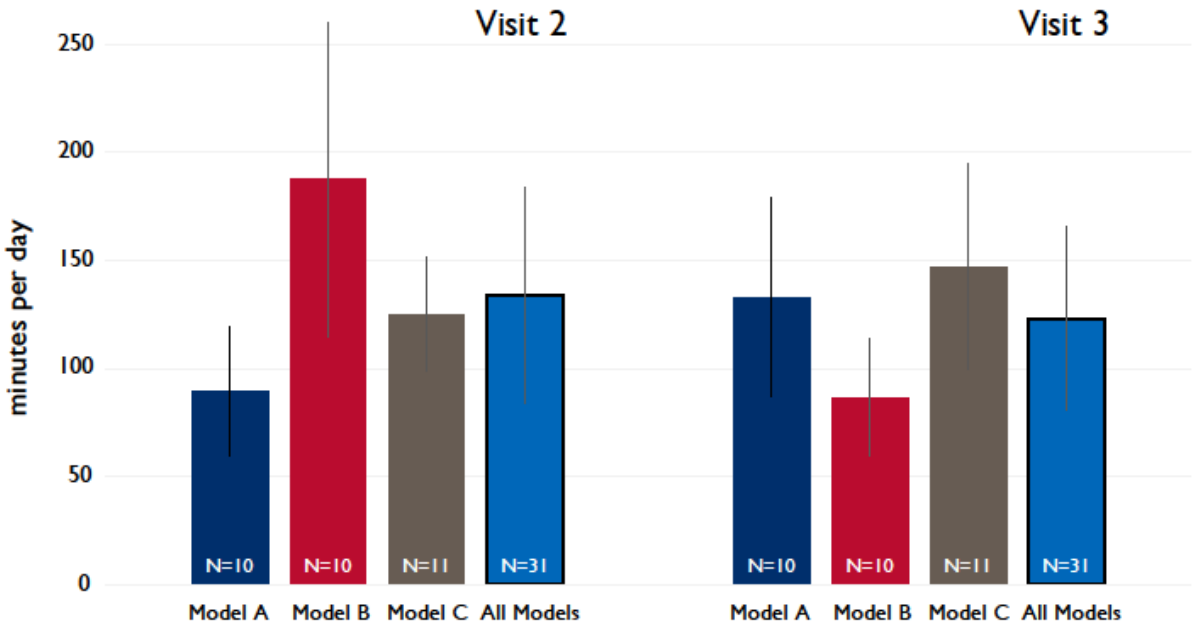
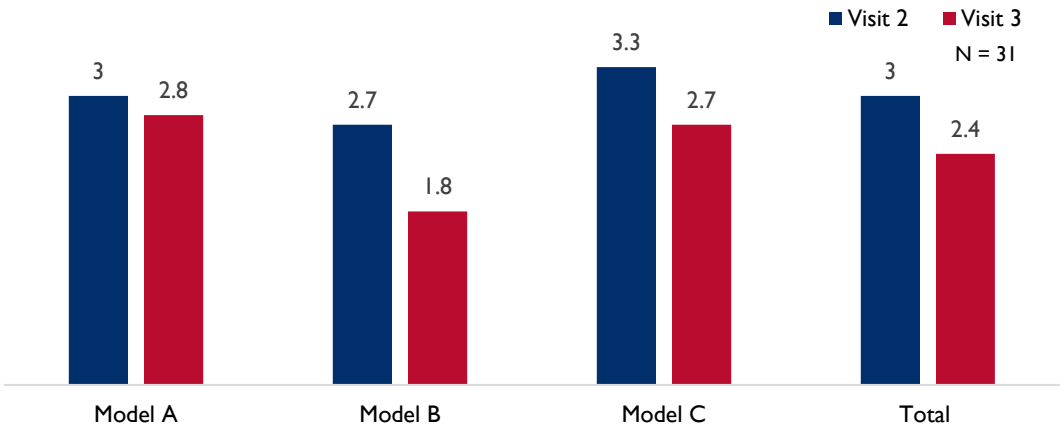


Figure 12 shows the average number of discrete occasions when infants were in the playpen was three times a day at Visit 2 and 2.4 times at Visit 3, with a range of 1.8–3.3 times/day by model at Visits 2 and 3.

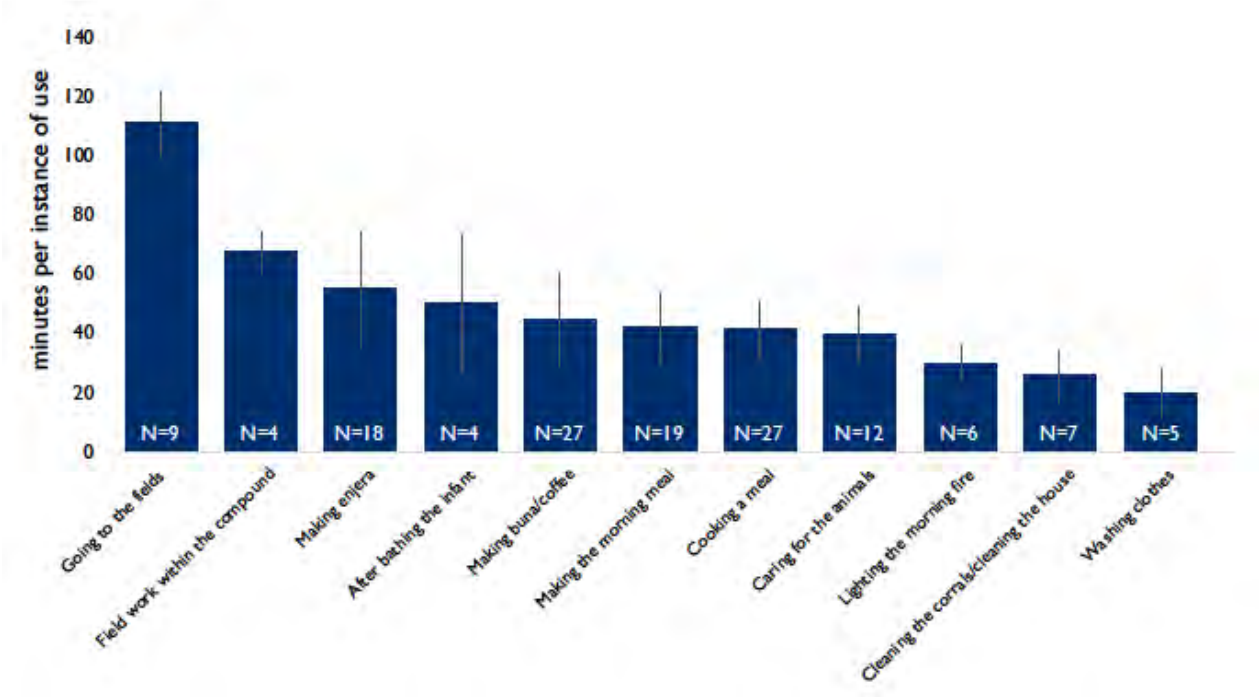
Figure 12: Average number of reported discrete occasions of infant playpen use in previous day



The average duration of infant placement in the playpen ranged from 20 to 55 minutes for tasks within the compound (with the exception of tending to compound garden plots, whose 4 reported instances averaged 67 minutes). Instances of use of the playpen for tasks outside of the compound, such as going to fields, were longer, averaging over 100 minutes. In the two cases where respondents reported using the playpen when they went to the market, the durations were 20 and 180 minutes, respectively. (see Figure 13).

Figure 13: Reported duration of playpen time per instance of use, across Visits 2 and 3, as reported through a 24-hour recall.

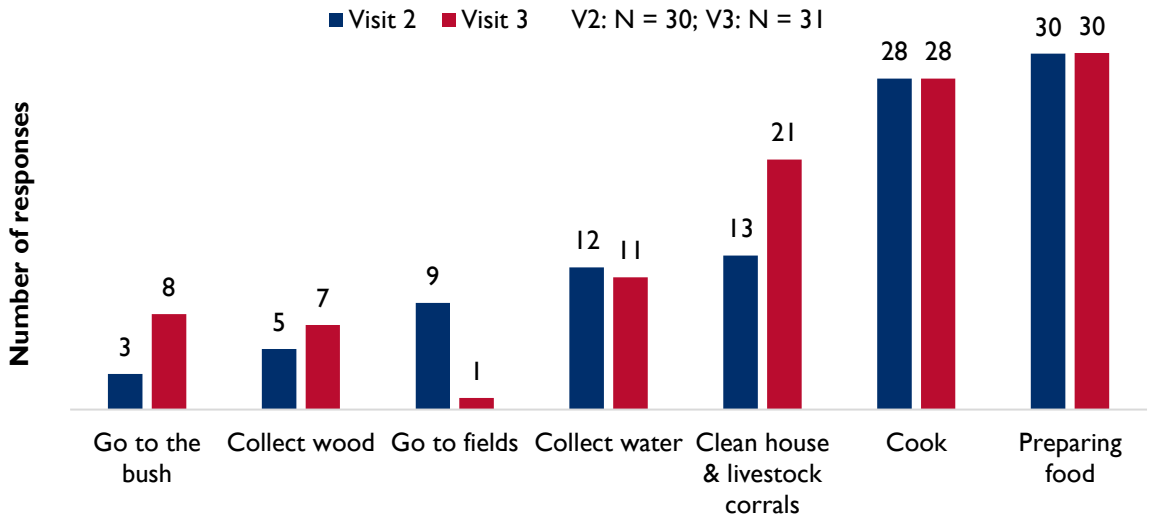
Error bars are standard deviations, and sample sizes are noted within the columns.



Caregivers did not report nighttime playpen use, and only a small number of caregivers (4 out of 31) said that infants and other children slept in the playpen at night when asked that question directly. Families only used the larger models (B and C) for nighttime sleeping. Nighttime use was not reflected in the 24-hour recall, therefore, is it not included in the average time spent in the playpen.

The team also asked caregivers (separately from the 24-hour recall measure) about their preferred situations for putting the infant in the playpen. As shown in Figure 14, caregivers responded that they preferred to use the playpens when while preparing food, cooking, collecting water and cleaning the house and livestock corral. Almost all caregivers during both Visit 2 and Visit 3 reported that it was most useful for them to use the playpens while preparing food and cooking. (Mothers report food preparation and cooking as separate activities.) The answers to this question varied between visits; most notably, playpen use while cleaning the house and livestock corrals increased from Visit 2 to Visit 3. During Visit 2, caregivers were far more likely to mention using the playpens (at home under someone else's watch) when they went to the fields compared to Visit 3, when only one caregiver mentioned using the playpen at home when they left for the fields. This is most likely because the third visit took place during the height of the planting season, when most family members were in the fields and so they brought the infant along. Participants did not mention collecting water as part of the 24-hour recall survey, but caregivers did so when asked, "For what activities did you find it most useful to use the playpen?"

Figure 14: Most useful occasions for using the playpen, by visit



Caregivers reported some differences in playpen use by model, although none was particularly notable; caregivers did not favor one model over another overall. Caregivers used Model A somewhat less while cooking and used Model C less while collecting water and more when cleaning house.

We also assessed whether households used the playpens properly and for the intended purpose according to the safety instructions. Data on observed playpen use was scant because playpens were often not in use during interviews and observation. In general, the playpens were on stable ground, in the shade, out of the path of smoke and at a safe distance from the fire pit. In a few instances, caregivers intentionally moved a playpen to the sun (still inside the home) to keep the infant warm. It was rare that caregivers placed the playpens within two meters of the fire; on the occasions when we observed it, we advised moving the playpen to a safer distance. Many households reported (and were observed) adding blankets or cloths on top of the playmats for cushioning, warmth and/or to absorb urine, and some added pillows. As international safety guidance discourages use of sheets, blankets or pillows due to risk of suffocation or strangulation, interviewers counseled against their use, encouraging instead that more clothing be put on infants. However, caregivers were often insistent that these extra items were essential to avoid a rash from chafing on the playmat, chills, or having the child play in pooled urine. (Half the infants wore some kind of pants, and the other half were bare-bottomed, as observed at Visit 1.)

4.4.2 CHANGES IN CHILDCARE PRACTICE WITH PLAYPEN IN THE HOUSEHOLD

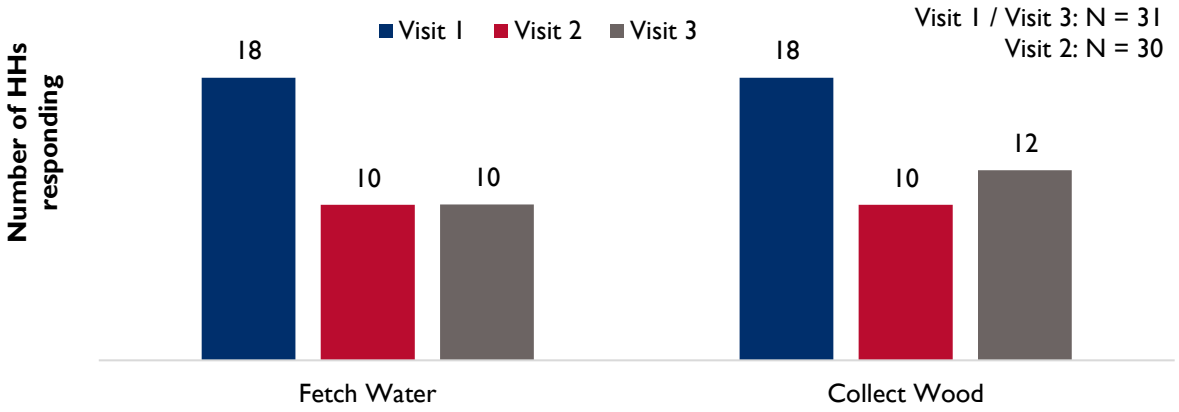
We asked caregivers about any shifts in childcare practices. Many (78%) reported that with a playpen, they were more comfortable leaving their infants with older children (while they collected wood and water), and 80% reported they were more confident watching their infants from a distance (for tasks such as preparing and cooking food). Similar patterns were recorded across the three models.

Meanwhile, the proportion of surveyed caregivers who reported bringing their infants to fetch water and firewood dropped after receipt of the playpen, from 58% (18 of 31) for both activities at Visit 1, to 33% (20/61) for water fetching and 36% (22/61) for wood fetching, combined over Visits 2 and 3. During these tasks, mothers usually left infants in the care of an older sibling.

Caregivers reported notable increases in their ability to watch infants while cooking, from 10 of 31 (32%) at Visit 1 to 22 of 31 (71%) at Visit 3. These reports are consistent with mothers reporting they

found cooking and preparing food the most useful times for using the playpen, specifically because they could watch their infants from afar while the infants were in their playpens, at a safe distance from the fire. Daughters and sons were also reported to increasingly watch the infant during cooking, although at frequencies far lower than mothers; it is likely that infants in their playpens were being watched by one or multiple family members.

Figure 15: Infant accompanying task, by visit



Daughters' responsibility for watching infant siblings while someone else collected wood increased after the households received playpens, from 7 of 13 (54%) at baseline to 15 of 19 (79%) by Visit 3. The incidence of sons watching the infant increased slightly. There were similar patterns for water collection. (Figures 16 and 17)

Figure 16: Person responsible for watching infant when wood is collected (if infant not accompanying collector)

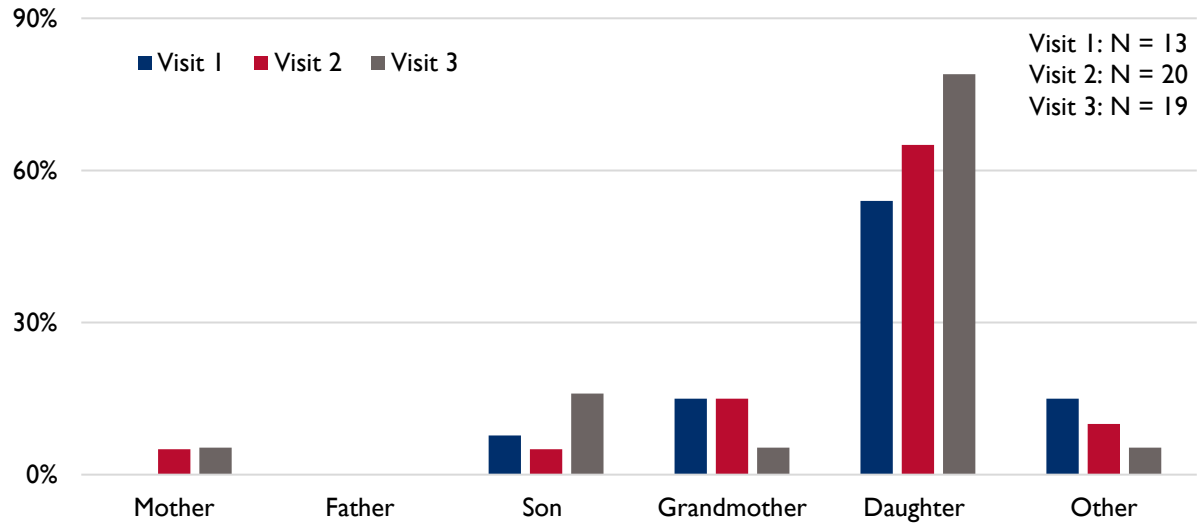
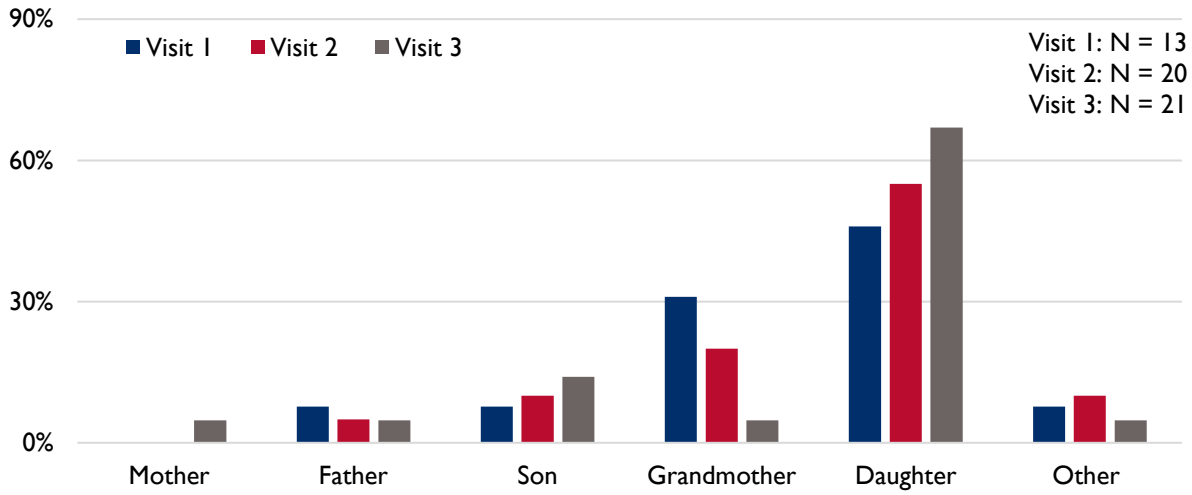


Figure 17: Person responsible for watching infant when water is collected (if infant not accompanying collector)



Infants increasingly accompanied household members during field and farm work over the course of the study, rising from 71% during Visit 1 to 90% during Visit 3. We interpret these data to reflect the intensification of farm work over the course of the study, as many family members helped with the planting season. Only two families reported bringing their playpens to the fields; both had the more portable Model A. In the other families, an older sister often watched the infants while family members worked the fields.

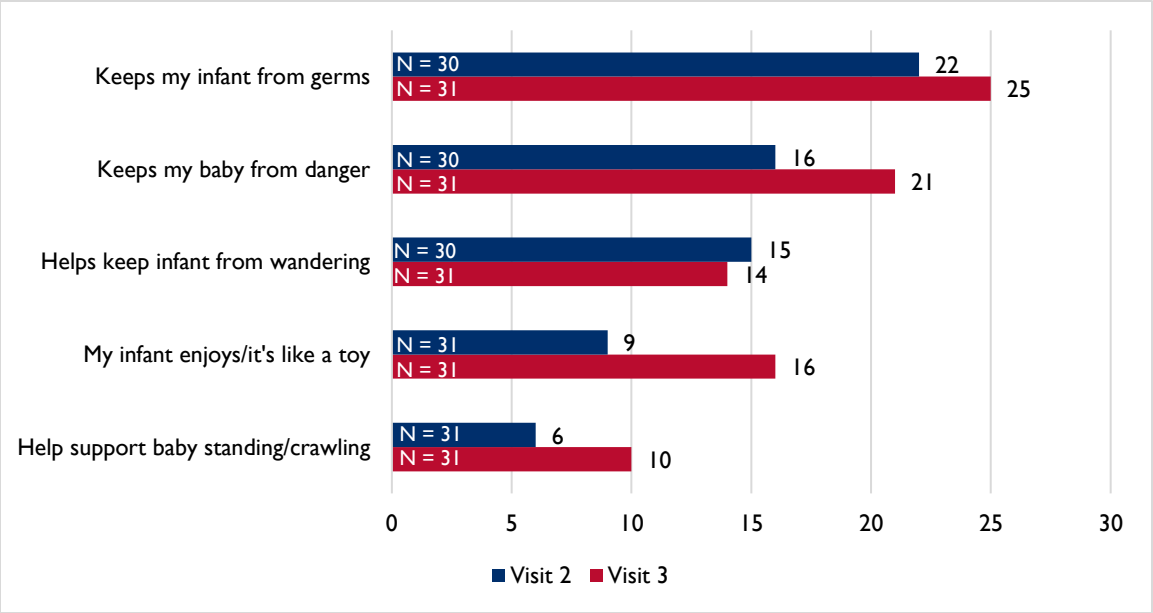
We found notable increases in the likelihood of mothers and sons watching infants in playpens while food cooked. The rate of mothers watching infants while cooking doubled across visits, from 10 of 31 (32%) at Visit 1 to 22 of 31 (71%) at Visit 3, while the rate for sons quadrupled, from 2 of 31 (6.5%) at Visit 1 to 8 of 31 (26%).

4.4.3 CAREGIVER REACTIONS TO PLAYPEN MODELS AND PLAYPEN USE

When asked several questions about how care-giving changed with the playpen, as well as "good things" and "bad things" about using a playpen to watch the infant, mothers named a range of benefits to the infants' hygiene, health, and motor development, as well as their own peace of mind and reduced physical and emotional burden. Caregivers reported an array of perceived benefits (see Figure 18). In many instances, endorsement of the playpens increased from Visit 2 to Visit 3, with caregivers increasingly perceiving that the playpens protected the infant from danger (from 16 of 30, or 53%, at Visit 2 to 21 of 31, or 68% at Visit 3) and germs (from 22 of 30, or 73%, at Visit 2 to 25 of 31, or 83%, at Visit 3). Caregivers were also increasingly likely to say that their infants enjoyed the playpens (29% at Visit 2, rising to more than half [52%] at Visit 3).] Interestingly, mothers mentioned without probing that their older children (also) loved to play in the playpen, with 7 of 31 mentioning at Visit 2 rising to 16 at Visit 3. At Visit 2, 6 of 31 households (19%) rising to 10 of 31 (32%) said the playpen helped the infant to stand and take steps.

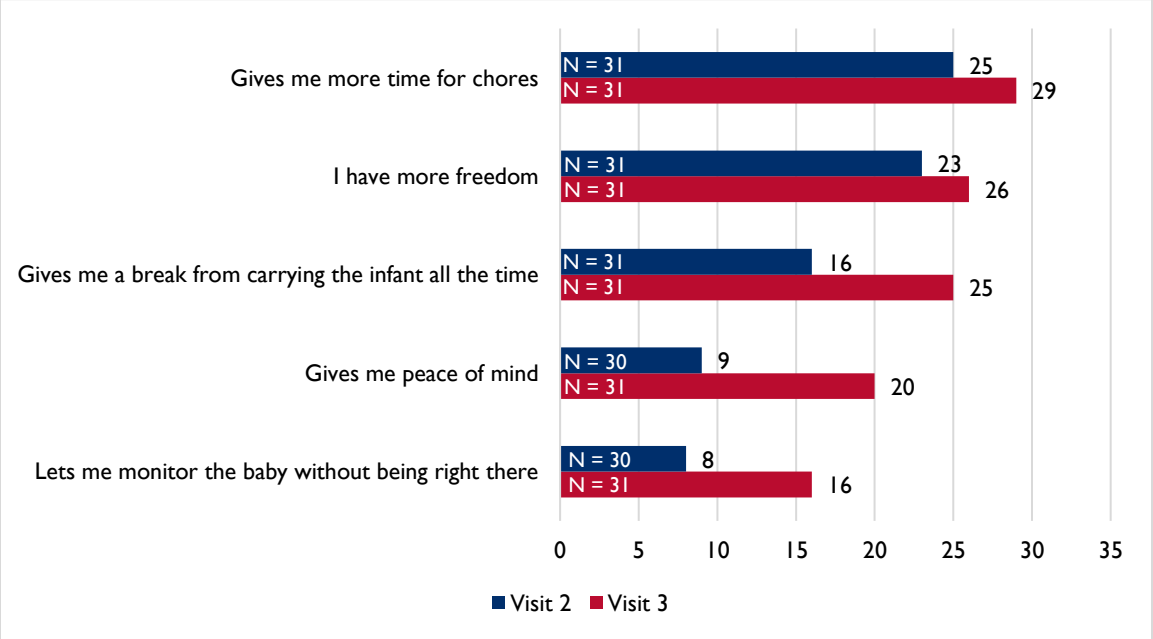
The qualitative data documented numerous benefits in the eyes of caregivers. Eight of the 31 respondents specifically mentioned without prompting that their children ate less dirt and feces now that they had the playpens. In the group discussions, numerous participants mentioned the playpens were useful to protect infants from wandering toward the fire and suffering burns.

Figure 18: Caregiver experience using playpen: focus on infant



In addition to benefits to the infant, caregivers recognized benefits for themselves and their older daughters (Figure 19). Caregivers increasingly noted the playpens made childcare easier, giving them more time for chores (25 of 31 or 81% at Visit 2, rising to 29 of 31 or 94% at Visit 3) and peace of mind (30% at Visit 2 and 65% at Visit 3). Additional benefits included making movement easier, not having to carry a child everywhere on their backs and having more freedom. In the group discussions, they said that now they have two hands to work with instead of one.

Figure 19: Caregiver experience using playpen: focus on caregiver



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that they had the playpens. In the group discussions, numerous participants mentioned the playpens were useful to protect infants from wandering toward the fire and suffering burns.

CAREGIVERS ON THE UTILITY OF THE PLAYPEN

"He is protected from fire, eating mud and chicken poop".

"Now, my baby … will not be vulnerable to danger like falling. Before we got access to the playpen, he tried to move out from the house and fall down and is hurt."

"I took it to the farm, and it helped me caring for him and protected the infant from eating mud and soil."

Only three mothers found their infants did not tolerate being in the playpen. Two of these mothers had no older children, and both mentioned it was difficult not having other children to help entertain the child in the playpen. Another mother who had just one child said that she offered candy to neighbors' children in return for them spending time in the playpen with her infant.

OBSTACLES, NEGATIVE CONSEQUENCES AND CHALLENGES TO USE

Caregivers reported no negative outcomes from using the playpens, even when prompted for specific physical, psychological or social examples. They articulated utilization challenges, as well as suggestions for improvement. Besides the three infants who did not tolerate being alone in the playpen, caregivers mentioned few child-related issues as challenges. Rather, the physical characteristics of the playpen were the primary challenges.

CAREGIVERS ON CHILDREN WHO DO NOT WANT TO STAY IN A PLAYPEN

"The playpen is very important to protect children from eating dirty things and from any harm, though my child is not willing to stay inside the playpen alone. I am trying to make her familiar but still now not willing to stay inside the playpen alone."

"The baby doesn't want to stay inside alone. She cries when I place her inside."

The most frequent challenges were the lack of an absorbent covering on top of the plastic mat to absorb urine, lack of padding under the mat or pen itself for cushioning (affecting comfort and to protect the infant from falls), and lack of an additional layer between the bottom canvas and dirt floor, to protect against insects congregating and breeding, condensation and cow urine. Many of the caregivers using Models A and C lamented the lack of a net covering to protect the infants from flies and mosquitos. (Model B had a mosquito net, so this was not an issue, although a few using the model mentioned the net was not long enough to make an insect-proof seal.) Some mentioned the lack of a sun cover, although few attempted to bring the playpens outside. Many respondents also mentioned the lack of portability and/or difficulty in disassembling the playpen as a challenge to using it more, cleaning it easily and taking it to the fields. However, only 2 of the 10 households using the smaller, easily disassembled Model A took their playpens to the fields. Another obstacle to taking any of the playpens to the fields was rainy weather, which created muddy conditions. The design of the Model C playpen presented specific challenges. Two thick, wooden support beams were exposed at interior ground level. Many caregivers recommended padding or covering the support frame.

Some respondents, particularly those with the larger 1.5 meter-square Model B, found the playpen too large for use in their common room. Although caregivers appreciated that the larger model

accommodated more children for play, they also said that it was difficult to move around the house or to bring outside.

4.4.4 FAMILY AND COMMUNITY RESPONSE TO PLAYPENS

Playpens generated a lot of interest in households and communities. Almost all caregivers reported both family and community approved of the playpens. They reported that husbands, elders, older siblings, and non-relatives were generally supportive and appreciative of the function of the playpens.

CARETAKERS ON COMMUNITY RESPONSE TO PLAYPENS

"People considered it a [stroke of] luck and encouraged us to use it properly. Additionally, it is taken as trendy, which goes with the time."

"[Neighbors] asked whether they can also have one for themselves… especially those who have infants and who are at fertility age are the ones who loved and asked frequent questions about it."

"Some say you are lucky and questions how I get this chance. They felt jealous about it and even blame my mother, that it is because my mother is working in kebele administration that I got the chance."

Many caregivers reported intense community interest and envy. (Almost all envy was reported as good-natured versus malicious.) Caregivers characterized neighbors as generally supportive and said many commented on that the playpen was a good thing. Others were curious to know how it worked and what was its function; caregivers reported they could confidently explain that the playpen helped create a safe zone and assisted in watching the infant. Some neighbors asked why the caregiver was lucky enough to be included in the study, and many asked how they too could get one of the playpens. Other neighbors commented that the infant was very lucky (with the focus of luck on the infant rather than the family). A few neighbors joked that connections to local administration or corruption explained household selection. One neighbor with older children teased she was going to have another baby just to try a playpen. Families lamented not being able to have a playpen forever. In addition to caregivers reporting these reactions, neighbors also made comments of this nature directly to the interviewers when visiting study households.

Anecdotally, community members frequently stopped interviewers on the roads and trails to inquire if they too could be included in the study. The team instructed interviewers to explain that only households with infants 7 to 12 months of age were eligible, and that the team used a lottery to select from those households. (The team used this explanation because villagers understood the concept of the random chance of a lottery.)

4.4.5 PLAYPEN MODIFICATIONS

The team assessed feasibility and appeal by monitoring any modifications to the playpens themselves or to their intended use. Just under half of households at Visit 2 and just over half of households at Visit 3 had modified their playpens to make them "easier" or "better" to use. Some caregivers with Models A or B added padding underneath the playpen to protect the underside from dirt and condensation. (Model C had the foam mattress so apparently additional protection was not necessary.) Some households placed toys in the playpen, in addition to the ball distributed with each playpen. Members of two households were concerned that Model C was unstable, so they added reinforcing string ties to ensure the two 5-cm bars in the frame did not fall on the infant. (The bar was at risk of falling only if an older child hit it while climbing into the pen; the lack of a door in this model made it difficult for other children to enter.)

4.4.6 INTRODUCING ADDITIONAL OBJECTS AND CHILDREN INTO THE PLAYPEN

The team installed playpens in households with a fitted, removable playmat of smooth reinforced plastic, known as *mintaf* in Amharic. Interviewers were interested to see if caregivers used the mat independently or always as a set with the playpen and, if caregivers the mat as a freestanding playmat, where, when and how they used it. Interviewers explored how well the removable playmat facilitated cleaning and maintenance, and whether caregivers perceived the removable mat as desirable.

Although researchers initially anticipated that some households might choose to use the playmat separately, they observed very few mats outside of the playpens. Interviewers found over 90% of playmats inside the playpen at both Visit 2 and Visit 3. Of 31 mats, researchers found two outside the playpen during a visit because they were drying after being washed and observed only one caregiver using the mat independently as a playmat for the child. We observed no non-child-related uses of mats (such as for drying grains).

Most households put toys in the playpens to help stimulate and animate their IYC most of the time during Visit 2 and Visit 3, (81% to 90%, respectively). Caregivers usually used the ball offered with the playpen at Visit 1, but in some cases also placed another object (such as an empty plastic bottle) in the playpen to entertain the child. The team observed different types of cloths, pillows and other household objects in the playpens in 29% of the households during both Visit 2 and Visit 3. We did not measure objects for fecal contamination but note that any object in the playpen can potentially be a source of contamination, detracting from the hygienic space we promoted to households.

During Visits 2 and 3, the team often observed older children playing in the playpens without an infant, most usually with another sibling other than the infant. Older siblings often used the larger Model B, with and without the target infant, for play, napping and eating. Model C had no door, so caregivers put the older children into it, or in a few cases, the caregiver placed the playpen close to a built-in bench along the wall to allow them to climb in.

Based on 24-hour recall, target infant's two major activities while in playpens were playing alone and playing with other children. More than half of the children played with other children (mainly siblings) in the playpen. At Visit 2, caregivers reported that 34% of the infants played alone and 40% at Visit 3. The other children playing with the target children were mainly siblings. The age of other people in the playpen varied significantly, from 2 to 25 years.

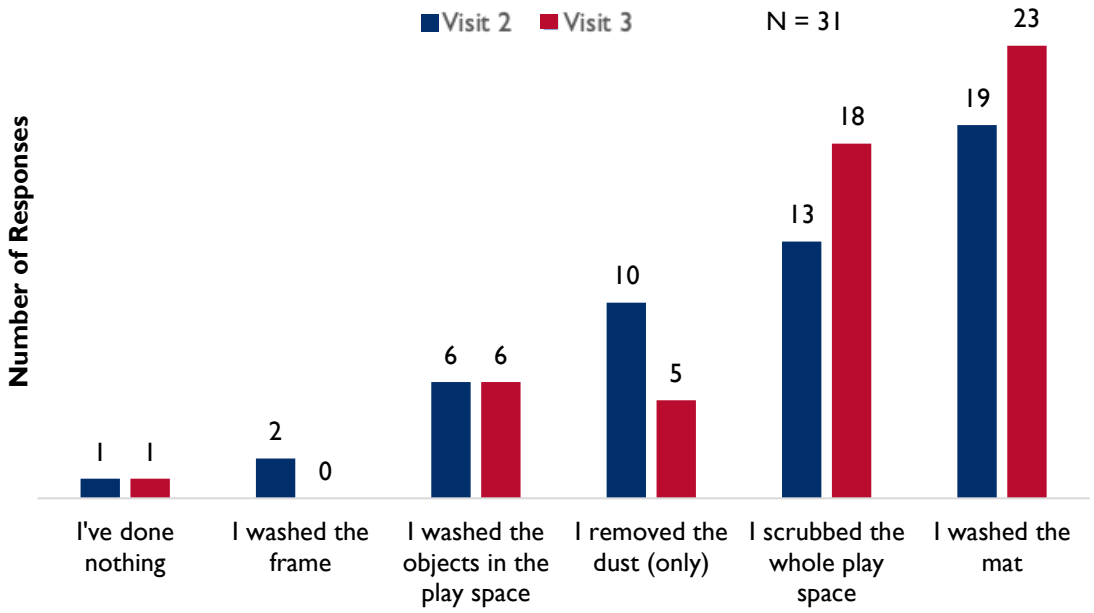
Playpen use by individuals other than the target child varied greatly by model. Not surprisingly, it was much more likely for other children (and adults) to be in the playpen with the infant in households that had the largest Model B playpen.

4.5 CLEANING AND MAINTAINING PLAYPEN

Maintaining a safe, hygienic zone for infants requires regular cleaning of playpens and playmats. The research team instructed household members to wash their playpens and mats at least every three days, or whenever they looked visibly soiled.

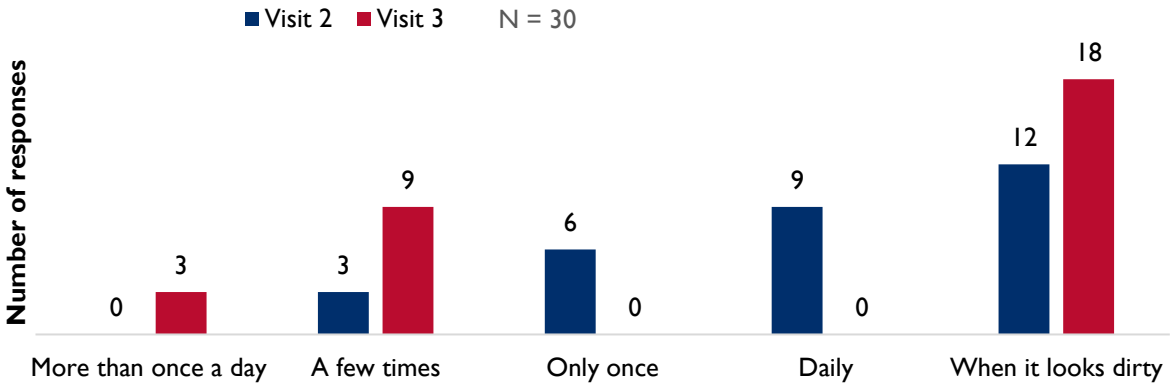
At both Visit 2 and Visit 3, researchers asked respondents how they cleaned and maintained the playpen "*since the last visit"* (over the past 7 to 14 days) and with what frequency. The majority of caregivers (74% during the Visit 3) replied that they washed the mat, and 58% reported that they scrubbed the whole playpen (20). (Figure 20)

Figure 20: Activities household members reported to clean or maintain the playpen



About half of the households (12 of 30, or 40% at Visit 2 and 18 of 30, or 60% during Visit 3) reported cleaning their playpens only when they looked dirty. At Visit 2, 30% of respondents reported cleaning daily, but none reported daily cleaning at Visit 3. At Visit 3, three of 30 (10%) respondents reported cleaning more than once a day, 9 of 30 (30%) reported cleaning "a few times" in the past week (Figure 21).

Figure 21: Reported frequency of playpen cleaning



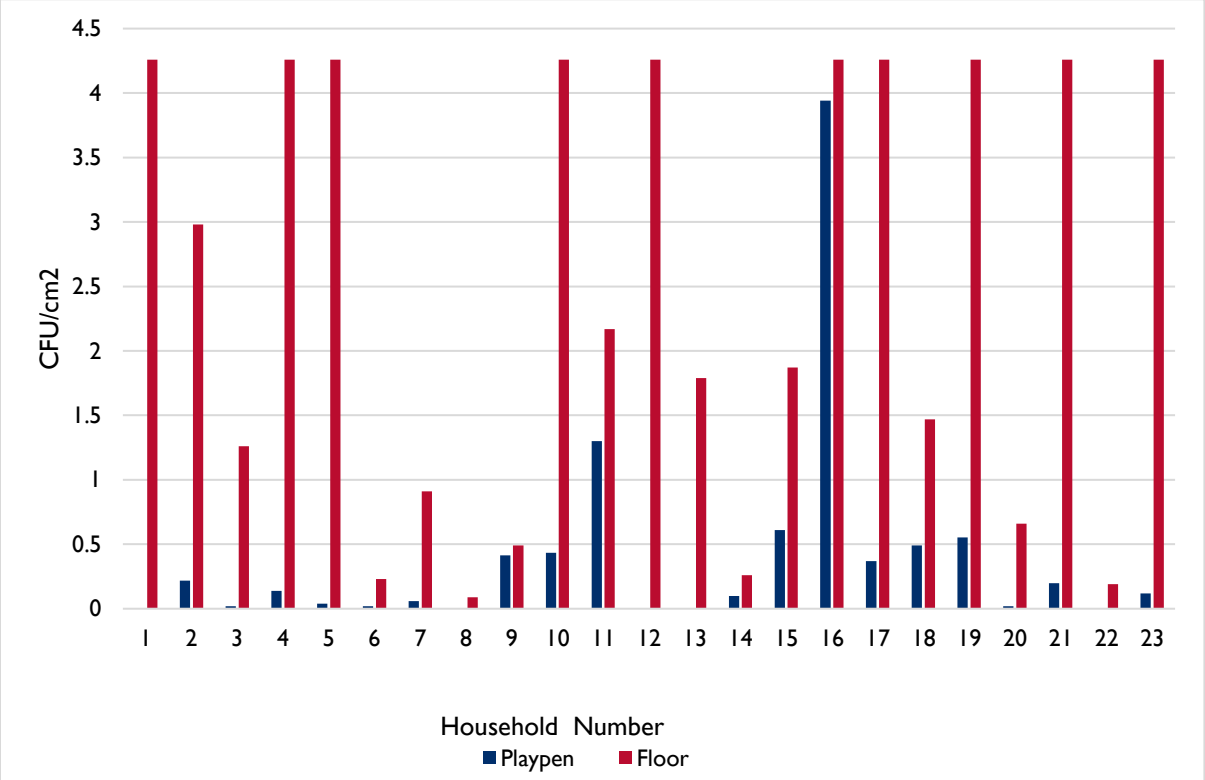
4.5.1 *E. COLI* SAMPLING TO MEASURE CONTAMINATION OF THE PLAYPEN AND FLOOR

During the final visit, the team took swab samples at 23 study households for *E. coli* analysis, as an indicator of microbial contamination of the playpen surface compared to other surfaces. The team took two swabs in each household: one from the living room floor and a composite swab of the playmat and the playpen rim.

E. coli was detected in 18 of 23 playpen/playmat composite samples tested after 3 weeks in study households, but at densities far below those of floors sampled in the same household (Figure 22). Six playpens were contaminated at counts below 0.1 CFU/cm^2, and all but 2 of the 23 playpens were <1.0

CFU/cm2. By comparison, 10 of 23 sampled floors were contaminated at the maximum detection limit of 4.26 CFU/cm2. (For reference, the Model C area totals 22,500 cm2, and the Model B area is 16,500 cm2. We detected no relationship between type of playpen and the contamination levels of the playpens.

Figure 22: E. coli counts in colony forming units per cm2 by density on floor and playpen-playmat composite



4.6 VALUATION/BUY-BACK OFFER

At enrollment, the research team told study participants that they would be trying the playpen for a few weeks, and then returning it at the close of the study. The team also informed participants that they would receive a small gift of appreciation for participation. When the research team completed the household data collection, however, they told participants that they were leaving the playpen as the gift, to which they responded positively and enthusiastically.

The team then offered participants the option of keeping the playpen or receiving a payment of 500 Ethiopian *birr* (approximately USD 17), the projected cost of a playpen if mass imported.

Respondents from all the participant households confirmed that they preferred keeping the playpen to a relatively large cash payout. Five of the 31 caregivers first consulted with their husbands before deciding to keep the playpen, one consulted with her mother-in-law and the remainder decided immediately.

5. CHALLENGES AND LIMITATIONS

The research team conducted the field work for this study June through mid-July 2019. Various factors influenced the timing of the stud. By the time the ethical reviews were complete in both Ethiopia and the U.S., and the playpens were constructed and inspected for safety, it was almost the Ethiopian rainy season (traditionally mid-June through August). We decided to proceed with data collection just before the rainy season began in early June, with frequent heavy rains at night but no rain in the daytime. The rains left compound yards soggy despite the hot midday sun and shifted much household activity, including playpen use, to the indoor common rooms.

Although the infant's primary caregiver served as the respondent in each household, other household members were often within earshot as they and their guests gathered in the one common room. Interviewers managed the dynamic by separating the caregiver from others in the room and, in some cases, asking to move to a more private location if side conversations were distracting or disruptive.

Caregivers participated in one individual and one group behavior change session designed to motivate them to establish a safe zone for their infants and to use and maintain the playpens. The sessions emphasized risks to health and growth, building on the Community-led Total Sanitation messages on preventing uncontained feces from ending up in food and water. Some of the content of those sessions seemed to be reflected in their responses to questions about "good things about the playpen" or changes since using the playpen.

Difficulties estimating time affected caregivers' ability to accurately estimate how much time their infants spent in their playpen for the 24-hour recall surveys. To address this challenge, the team trained interviewers to guide estimations based on familiar intervals, such as the time required to reach the road or make *shiro* (a common traditional food of ground legume). This approach provided some standardization in the responses regarding time intervals.

An attempted regional coup in late June caused an unanticipated week-long gap in study visits while roads were closed by government mandate, internet and text communication were severed and conditions were not stable enough to travel to the study villages. Due to the conditions in the aftermath of the coup attempt, the interval between visits varied between the two *kebeles* or wards. In Debranta *kebele*, there was a one-week interval between Visit 1 and Visit 2 and a two-week interval between Visit 2 and Visit 3. In Feriswoga *kebele,* there were two weeks between Visit 1 and Visit 2, but one week between Visit 2 and Visit 3. We detected no impact of this variable interval between visits. We decided not to extend the field work an additional week to standardize intervals between visits because future political conditions were uncertain, with the rains intensifying by the week.

Due to security conditions in the country, the government shut off internet access for two different week-long periods (one week preceding the coup attempt to deter cheating on a week-long national exam and another week during the political instability following the coup attempt), allowing only brief, periodic access at unpredictable times. This made it impossible to monitor data collection from off-site and also made downloading survey updates and corrections difficult.

6. DISCUSSION AND RECOMMENDATIONS

6.1 WERE PLAYPENS APPEALING?

Appealing to caregivers and families. Playpens were appealing to the vast majority of caregivers and families. It is critical to underscore that both the benefits brought by the playpens, as well as the physical playpen and playmat, were popular and pleasing. The buy-back offer results, along with numerous testimonials speak to how highly they were valued. These results highlight a potential commercial opportunity for play pens in Ethiopia in which the feasibility of mass production or importation of a playpens could be explored.

Appealing to neighbors and community. We conclude that playpens and the concept of a safe zone for IYC were acceptable and appealing to the broader community. Local leadership endorsed the playpen concept after participating in an initial community session introducing issues with IYC exploratory mouthing and proximity to animals and receiving an invitation to participate in testing a playpen solution. They all agreed to support the trial of playpens to maintain needed safe zones for IYC in their villages. The only negative reactions or interactions reported by study participants were that some HEWs and local officials were not happy about their households not being included in the study pool and thus not having an opportunity to try out the innovation of a playpen. Both adjacent and non-contiguous households in study villages knew about the variety of playpens placed in participating households. Few respondents or their families reported doubts about its safety or suitability, or negative comments about their use of a playpen, as reported in previous playpen studies (Reid et al, 2018), and the those few negative comments were only mildly negative.

Local officials, study guides (who were respected community members) and interviewers received multiple requests for inclusion in the study and use of a playpen from both male and female community members who were not selected for study participation. Most seemed to understand the playpens were to be left in the households for only the three-week study period, but this did not quell their enthusiasm to share the experience of the novel playpen. Community members accused several guides of showing favoritism to family and friends and suspected interviewers of bringing the team to households of their choosing. However, household selection was in fact random among all households meeting the inclusion criteria. To calm accusations, interviewers attempted to explain in person that researchers used a "lottery" system, a concept well understood by the villagers, select participants. A shopkeeper who offered his storeroom as a staging ground for playpen placement in his *kebele* lobbied intensively over several days to be gifted a spare playpen to use with his young daughter rather than cash payment for lending his space.

6.2 WAS USE AND MAINTENANCE FEASIBLE?

6.2.1 FEASIBILITY OF USE

Overall, caregivers, siblings and other family members considered using the playpen feasible. With the exception of the three infants who did not adapt to the playpen, all other mothers reported their infants were content in the playpens. The net sides that enabled supervision from a distance were often named as enhancing feasibility of use, as were the bug net of Model B and the soft sponge mat and built-in stimulation and entertainment of Model C. Many said that the infant required entertainment, particularly an older sibling, to keep them company while in the playpen. Several caregivers with only an infant and no other children mentioned it was more difficult to use the playpen, because the infants became restless and fussy without company. Caregivers considered Model A too small for multiple siblings to play in at once, which inhibited use. Conversely, the bigger Models B and C had space for several

children at a time and increased the feasibility of use. (The 24-hour recall did not confirm higher use of the larger models, but it is possible this was due to the mothers' inability to accurately estimate time and reluctance to admit that multiple children sometimes slept all night in a playpen). One factor that limited extended use of the playpen was that all the infants in the study were actively breastfeeding, and they often became discontent when hungry or insecure, wanting to return to their mothers. Older infants might be more independent and willing to stay longer in the playpens but are also more mobile and curious, which might limit time in the playpen.

Lack of portability, to bring the playpens outside and to the farms, also may have limited feasibility of use. The team conducted the study during planting season, when most family members spend significant portions of their day in the fields. Only Model A was easy to assemble and disassemble and easily carried by one person with one hand. Models B and C were difficult to assemble and disassemble, and too heavy and unwieldy for a single person to carry, even with two hands. We also note, however, that caregivers only used Model A on a few occasions in the fields. Factors beyond portability (like muddy paths and fields) likely also played a role, given that the households were operating on the assumption that the playpens were only on loan (and despite reassurances that they could use the playpens as they wanted, the study participants were likely reluctant to get them too dirty).

Model C, the one model without a door, was harder for older siblings and playmates to get into either to use by themselves or with their younger siblings. It was equally difficult for siblings to reach over the playpen sides to place the target infant in the playpen or to take them out. Two households placed their playpens close to a raised mud bench built against the wall of the home to serve as a stepstool for the small but older siblings.

6.2.2 DETERMINANTS OF USE

Because all study participants used the playpen, we were unable to contrast a profile of users and non-users of playpens, and cannot report which determinants (risk perception, product access, self-efficacy, key skills and knowledge, or social norms) drove behavior.

The concept of a safe zone (in contrast to a focus on *using the playpen)* resonated with caregivers and families and encouraged not only use of the playpen, but overall maintenance of a special, safe area just for infants. Many mothers mentioned that a benefit of using the playpen was that their infants' clothing remained cleaner and could be washed less frequently. Mothers also reported that their infants ate less dirt and feces (the main objective of establishing a safe zone). The latter suggests *increased knowledge and perception of ris*k of soil and feces.

The provision of a playpen clearly *boosted caregiver self-efficacy* to establish a safe zone for their infants. Mothers and fathers gave extensive testimony that before learning about playpens, they did not think it was possible for resource-poor farmers to keep their children from dirt and feces, but now with a playpen they saw it was possible. At the close of household visits, householders confirmed the playpen was effective in creating a safe zone. They noted a few additional attributes, when specifically asked, such as "keeping the chickens away" (without specificity), modern chicken houses, generally "keeping clean," or "use sacks to keep the infant off the dirt," but the majority thought a playpen was the best way to consistently block their infants from contact with dirt and feces.

In Amhara and perhaps other parts of Ethiopia, families "clean" their homes by spreading a fresh layer of cow manure on the household surfaces. In several households, we observed that caregivers covered the ground around the playpen with fresh manure, apparently to comply with our recommendations to keep the area around the playpen clean and safe for the infant. Although cow dung presents less risk than poultry and other animal feces, future messaging must address the perception that cow dung is clean.

6.2.3 FEASIBILITY OF MAINTENANCE

Discussion of maintenance is best reported by separating maintenance of the removable plastic playmat and the larger playpen structure. Respondents appreciated the removable mat and universally felt it facilitated cleaning, reporting that both the washable material and the portability of the mat facilitated removal and cleaning.

Mothers reported moderate cleaning of the playpen, with about half of households reporting thorough cleaning of the entire playpen "whenever it looked dirty." A few respondents did not seem concerned with the need to routinely clean the playpen in the absence of visible dirt. In one instance, a chicken defecated from the rim to the inside of the playpen, and caregivers made no effort for the following 45 minutes to clean the feces as two children (not the target infant) played in the playpen. (Before departing the household, interviewers recommended washing the playpen with soap and water, pointing to the flies gathering on the feces to motivate prompt cleaning.)

We observed and respondents reported several issues regarding the feasibility of maintaining the hygiene of the playpen. We selected study villages with medium to high access to water specifically to ensure that water access was not a limiting factor in maintaining the playpens. Some households, however, did mention challenges with water access limiting their ability to clean the playpen and mat. Proximity to the water source (and the lack of portability of the playpen), rather than lack of access to water, was the issue.

Participants stated that limited portability and the ability to disassemble the playpen were obstacles to cleaning it. Ease of assembly and disassembly were certainly inhibited by production issues. However, even if current designs are ideally produced, models B and C are cumbersome to assemble and disassemble and a bit heavy to carry.

Several caregivers mentioned that because their children did not wear pants, they frequently urinated and occasionally defecated on the playmat. They noted the utility of the mat for cleaning, but also recommended placing the infant on an absorbent sheet or cloth to avoid having the child sit on the wet mat and to facilitate cleaning. While practical, this suggestion contradicts safety recommendations to minimize the suffocation or strangulation risk that a sheet or blanket presents.

Several participants mentioned and interviewers observed that the practice of tethering cattle, primarily at night, led to urine-soaked floors inside the houses, sometimes quite close to the playpens. The odor of cattle urine is associated with illness and unhygienic conditions. Household members suggested adding another plastic liner underneath the playpen to separate the playpen from unhygienic conditions.

6.3 ARE PLAYPENS A POTENTIAL SOLUTION TO HELP PROTECT INFANTS AND YOUNG CHILDREN FROM EXPOSURE TO HARMFUL PATHOGENS?

With growing interest in better understanding the complex pathways of child growth and development, and the call for "transformational WASH," are playpens part of the solution?

This research documents that playpens were appealing to caregivers and their families, who perceived a range of benefits from playpen use. Most study participants used the playpens on a daily basis, but even the most enthusiastic caregiver had her child in a playpen for just a small proportion of the waking day.

The infants in the study were in the playpens for about two hours a day, but we don't know how much time they spent on the ground (whether mat, dirt floor or other) or how much risk and contamination were averted. Little is known about thresholds of exposure and how they affect health and growth; the study did not establish, for example, whether reducing pathogen transmission by one-quarter (or one-half) provides sufficient protection to bring about significant benefits. Despite hours spent in the playpen

each day, an infant's brief time spent on dirt floors may still lead to direct pathogen ingestion via geophagy or other means.

Secondary analyses of the SHINE trial findings indicate that time spent on a play surface that limits geophagy and mouthing leads to reduced mouthing when infants are off the play surfaces as well, suggesting that IYC form different habits through use of a protective play surface that may reduce overall exposure to pathogens (Humphrey et al., 2019; D. Fundira, Personal communication, November 1, 2018).

In addition, a number of the practices reported and observed in this study have high potential to contaminate the playpens and expose infants to pathogens. Specifically, older siblings with unwashed and visibly dirty feet and clothing used the playpens with the infants and independently, likely contaminating playpen surfaces. The team observed chickens on the rim of playpens, as well as inside some of the pens (either flying in or entering through an open door). Most playpens exhibited *E. coli* contamination even within the three-week period of study.

Based on the results of this study, playpens alone cannot plausibly provide protection to IYC from environmental contamination. Promotion of playpen use would certainly need to be part of a more comprehensive effort to maintain a hygienic environment. The importance of animals to the well-being of rural households, lack of boundaries between human and animal domains, fear of livestock theft, low perceived risk of exposure to poultry feces and no perceived risk of exposure to cow dung create immense challenges to maintaining such a safe zone. A lack of hand hygiene reflects, in part, the low perceived risk of animals and their feces as a disease pathway.

Separating IYC from animals was not a new concept to the study participants, because it is stressed as part of the HEWs messaging to households, but it is one they felt was too challenging to achieve in their agricultural environment without an aid such as a playpen. This study demonstrated that access to the enabling technology of a playpen, together with promotion of a safe zone, bolstered efficacy and intention to reduce infant exposure to pathogens.

6.4 NON-WASH BENEFITS ATTRIBUTED TO PLAYPENS

The study also identified a number of other perceived benefits of playpen use for caregivers, IYC and other siblings that are noteworthy and support further exploration of the biological plausibility and commercial viability of scaling up playpen promotion for disease prevention in rural, agricultural households. These additional benefits are:

Reduced burden on women, with possible impact on mental health. Mothers attested to the relief they felt when using the playpen, including physical relief from carrying children on their backs while completing other chores, relief from needing to watch children as carefully and relief from worry about children getting injured. The study also documented that most mothers said having the playpen made childcare and other housework easier, freeing both hands for work. In addition to reducing the burden on the mothers' health and well-being, the benefits could also improve child health. The impact of maternal stress and depression on child growth is clearly documented (Surkan et al., 2011), including reduced interaction and responsive feeding, directly affecting child nutrition and growth.

Reduced burden on young girls. Older girl siblings, who are often very young themselves, are regularly tasked with watching their younger siblings, which includes carrying them on their backs. Relieving young children from this physical burden is another benefit of playpens. These siblings can now watch the infant from outside the playpens or play inside the playpen alongside the IYC. As discussed earlier, however, use by older siblings with unwashed muddy feet, soiled clothing and unwashed play objects certainly increases the likelihood of adding contamination to the mats and playpens.

Other possible health benefits. Women mentioned using playpens while cooking *enjera* (traditional bread), roasting coffee, and preparing other foods on the open fire. Cooking emissions and the resulting household air pollution (HAP) have a documented relationship to childhood pneumonia, and recent research highlights that HAP may also increase the risk for anemia, childhood stunting and impaired cognitive development. Reducing IYC exposure to direct, intensive HAP may have an impact on a range of health areas and child growth (Clean Cooking Alliance, 2019).

These results support further exploration of the potential benefits and commercial viability of scaling up use of playpens in rural, agricultural households as part of a comprehensive approach to IYC development and women's empowerment.

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ANNEX A: THREE PLAYPEN MODELS TESTED IN TIPS

Model A – Imported

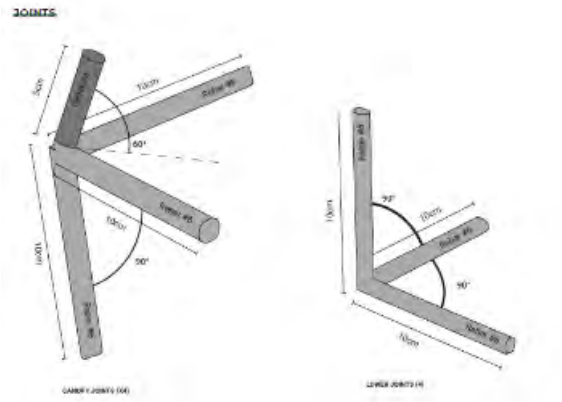
Made in China (North States Design Brand)

- Hexagon shape, 66.5 x146 cm *(approximately 58″diameter, 26″ height)*
- Structure: frame from PVC tubes and joints
- Walls: 5 netting, 1 solid canvas with curved zipper door opening
- Floor: solid, durable canvas
- Easily assembled/disassembled in 5–10 minutes
- Removable, washable, fitted playmat

Model B – Produced locally in Ethiopia

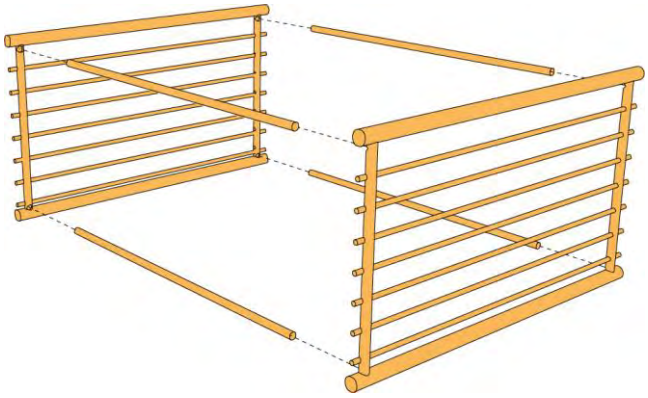
Square with net canopy

- Square shape, 170 x 170 x 70 cm for multiple children *(about 68 ″ x 68 ″ x 27.5 ″)*
- Structure: PVC tubing with welded rebar metal joints (joints also fabricated in-country), too large for child to choke or swallow if loose
- Walls: 3 sides with large net windows
- 1 solid canvas side with large door, flap opening with string/button closure
- Removable, washable, fitted playmat
- Frame canopy with mosquito net



Model C – Produced Locally
Stimulating "Toy" Bottle Walls

- Rectangular shape, 150 cm x 110 cm x 70 cm *(about 59 ″ x 43 ″)*
- Structure: Wood frame
- Walls: Two sides with large net windows
  - Two sides with recycled PVC water bottle walls for child entertainment and stimulation
- Removable, washable playmat
- Bare foam padding under playmat
- No door, no canopy net



ANNEX B: USER-CENTERED PLAYPEN DESIGN WORKSHOP REPORT

USAID WASHPALS USER-CENTERED DESIGN WORKSHOP REPORT: CO-DESIGNING A SAFE PLAY SPACE FOR INFANTS AND YOUNG CHILDREN

DECEMBER 2018

DISCLAIMER

The author's views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

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CONTENTS

LIST OF FIGURES

ACRONYMS

cm	centimeters
DIY	Do It Yourself
EED	Environmental Enteric Dysfunction
IYC	Infants and Young Children
mm	millimeters
NGO	Nongovernmental Organization
PET	Polyethylene Terephthalate
PSI	Population Services International
PVC	Polyvinyl Chloride
TIPS	Trials of Improved Practice
TVET	Technical and Vocational Education and Training
UCD	User-Centered Design
USAID	United States Agency for International Development
USD	United States Dollar
WASH	Water, Sanitation, and Hygiene
WASHPaLS	Water, Sanitation, and Hygiene Partnerships and Learning for Sustainability

EXECUTIVE SUMMARY

USAID's Water, Sanitation, and Hygiene Partnerships and Learning for Sustainability (WASHPaLS) project engaged Population Services International (PSI)/Ethiopia to conduct a user-centered design (UCD) workshop aimed at developing locally sourced, affordable playpen models for use in upcoming research to test whether playpens protect infants and young children (IYC) from exposure to harmful pathogens affecting growth.

PSI/Ethiopia and FHI 360 held the week-long UCD workshop in Bahir Dar, Amhara, Ethiopia from August 22-29, 2018, bringing together 15 users—mothers, fathers, health extension workers, local artisans, vocational college instructors, and others—to develop the playpen models. The team placed participants into three groups, and each developed a playpen prototype with distinct attributes. Although originally tasked with developing do-it-yourself (DIY) prototypes to be locally crafted by artisans or mass manufactured in Ethiopia, the groups did not do so, in part because of the introduction of the imported Chinese model. The iterative design process yielded three models that could be modified for production in any of the three categories: DIY with local materials by inexperienced builders (local community); local production made of local or regional materials by skilled artisans and masons; and large-scale manufacturing made of regional or nationally available materials by professional builders or factory.

Parents and community members tested miniature mock-ups and life-size prototypes in two rural communities in Bahir Dar Zuria. Overall, target users grasped the concept of a safety zone for IYC and liked all the prototypes. Many felt the idea of a playpen would create a safe zone and facilitate household chores; however, some stated this was probably something for "city folk."

Post-workshop next steps are to consolidate the best prototype features into two distinct final designs for better comparison in field trials. Participants, including rural parents, other community members, and child development experts all provided feedback regarding playpen assembly method, dimensions, and materials.

The local technical and vocational education and learning (TVET) center will finalize and reproduce the design at small scale. These prototypes will then be used in a USAID/WASHPaLS research activity to test if a playpen protects IYC from exposure to harmful pathogens affecting growth and development. While not the focus of this report, the workshop also achieved secondary objectives of building participants' skills and efficacy to address challenges using the design process.

1. BACKGROUND

Uncontained animal feces and objects contaminated with animal feces are abundant in rural areas in developing countries and can be linked to environmental enteric dysfunction (EED). Infants and young children (IYC) ingest contaminated soil and animal excreta in their domestic environment through exploratory mouthing of objects and direct ingestion, which exposes them to pathogens, leading to EED. EED affects the lining of the small intestine and can lead to undernutrition and stunting. Play space and play mat products have recently been proposed as possible interventions to reduce IYC exposure to pathogens in the domestic environment.

In Ethiopia, approximately four in ten children are chronically malnourished and stunted. Past efforts and interventions to reduce stunting have focused on treating dietary needs and the six Fs from Wagner and Langlois' "F-Diagram" (fluids, fingers, flies, fields, fomites, and food). Such strategies have addressed improved water supplies, drinking water quality, hand hygiene, and sanitation measures, but do not directly address the separation of IYC from animal feces and dirty objects. The use of playpens is an option to disrupt this contamination pathway. However, there are no published studies that document that safe zones for children prevent contamination and improve health.

USAID's Water, Sanitation and Hygiene Partnerships and Learning for Sustainability (USAID WASHPaLS) project is conducting field research in Ethiopia to explore the potential of hardware and behavioral measures to reduce exposure risk of IYC to microbial pathogens in home environments, particularly from animal excreta, geophagy, and fomite mouthing behaviors of very young children. The research seeks to answer two central questions:

Primary: Does a protective play space product (playmat and playpen) and accompanying behavioral intervention significantly reduce exposure of IYC to harmful enteric pathogens?

Secondary: How consistent are play space use and maintenance, and what behavioral determinants most influence consistent use and maintenance of such a product?

As the first stage of a process to assess biological plausibility and effectiveness of protective play spaces, USAID WASHPaLS project contracted Population Services International (PSI)/Ethiopia (lead implementing partner of the Transform Water, Sanitation, and Hygiene [WASH] Activity) to organize a seven-day user-centered design (UCD) workshop to create and evaluate locally viable versions of playpens. USAID WASHPaLS will test the playpen designs in Trials of Improved Practice (TIPS) through household testing of childcare practices to improve and refine design specifications.

2. WORKSHOP OVERVIEW

A UCD workshop is configured to generate feasible and sustainable solutions to a shared problem by involving key technical and community stakeholders (the "users" or implementers of the solutions and technologies) in an iterative, guided process. Different stakeholders are invited to learn about the design process, related tools and frameworks and collaboratively design solutions through hands-on activities made to engage and to encourage skill sharing and knowledge exchange among all involved, organizers and participants alike (Figure 1).

Figure 1. Collaboratively modelling solutions to gather feedback for further iterations

Among the more important benefits of the participatory design approach is the opportunity of working, sharing, and exchanging knowledge, skills, and technology with different stakeholders. The stakeholders are exposed to different perspectives on the same problem, discuss solutions, and develop a prototype of the final design together. These activities provide a multidisciplinary environment for problem solving, and empower participants, giving them voice and agency.

Organizers held the UCD workshop in the town of Bahir Dar, Amhara over the course of seven days (August 22-29, 2018). The Bahir Dar Institute for Technical and Vocational Education and Training (TVET), a resource partner for Transform WASH, provided classroom and workshop spaces for the activity.

PSI/Ethiopia recruited members from key stakeholder groups to form a heterogeneous group of 15 participants. The selected stakeholder groups represented different perspectives on the playpen/play space issue. The participant group included:

- Three mothers,
- Three fathers (dissociated from the selected mothers),
- Three health extension workers,
- Three TVET instructors,
- Two masons, and
- One nongovernmental organization (NGO) representative.

Two of the three mothers participating in the workshop brought their children, ages 16 months and 28 months. The toddlers, although somewhat older than the target group for playpens, provided "live" data and confirmed information related to the children's daily behavior, helping the group with feedback after tests.

Since the aim of the workshop was to develop a maximum of three playpen prototypes using a range of manufacturing options, facilitators divided the participants into three heterogeneous groups that

included roughly one participant from each of the above categories. In addition, the facilitators prompted each group to focus on one of the three manufacturing possibilities (Figure 2):

1. Do-it-yourself (DIY) - made of local materials by inexperienced builders (local community)
2. Local production - made of local or regional materials by skilled artisans and masons
3. Large scale manufacturing made of regional or nationally available materials by professional builders or factory

Figure 2. Division of participants across product categories

3. WORKSHOP SUMMARY

The workshop facilitators presented the design process as a three-step cyclical process to produce improved iterations and understanding of the risks associated with exploratory child mouthing behavior in unhygienic environments. They conducted group activities to illustrate how the process works (Figure 3). The three stages of the process are (1) Gather Information, (2) Generate Ideas, and (3) Develop and Test Prototypes. Facilitators also formed the teams during this stage.

Figure 3. Facilitator explaining the steps of the design process

1. Gather Information

This stage began with a clear illustration of the risks associated with exploratory child mouthing behavior in unhygienic environments, and how it may significantly influence IYC physical and cognitive growth. The facilitators subsequently introduced participants to the notion that a "safe zone" for IYC could potentially block exposure to harm. The group then generated a list of additional information required to inform the design process and interviewed participants from each stakeholder group to understand their routine, goals, needs, and resources, as well as their perception of the problem. Sessions with invited WASH, child development, and health experts helped participants understand the relationship between safe play spaces and child health, and safety requirements for designing playpens. Facilitators explained the specific design requirements such as cost, usability, gap dimensions, height, materials, and finish types during this phase and linked them to potential safety issues.

2. Generate Ideas

To encourage participants to think creatively and freely, this stage began with creative thinking warm-up activities closely followed by brainstorming sessions to generate possible safe zone or playpen designs meeting key criteria. Participants then grouped the ideas generated to form multifaceted concepts that addressed issues expressed by the different stakeholder groups. Later, the groups used sketch modelling (making miniature mock-ups) to better understand and visualize the ideas generated. In addition, a mass-produced Chinese playpen was presented during this stage as an example of a large-scale manufactured product with design attributes that make it safe and portable. The commercial playpen allowed participants to interact with and test the idea of using safe zones with the toddlers present at the

workshop. It influenced the groups' decisions going forward as they aggregated specific features of the design into their own solutions. One team, however, pivoted from their concept and decided to adopt the Chinese design and adapt it to local materials and resources.

3. Develop and Test Prototypes

Each group took one to three sketch models to a rural community visit in Bahir Dar Zuria and interviewed mothers and caretakers to get feedback on the various attributes of the models and select one "winning" concept to move forward with further iterations (Figures 4 and 5). The selection of the winning concept was largely based on the comments received from interviews and construction feasibility. After an introductory session on workshop safety and tool use, the working groups incorporated feedback from their field visits into the concepts and built prototypes of their final design to scale over the course of two days. Upon completion of the prototypes, participants carried out a second field visit to the same community to collect additional feedback from an expanded sample, including the original group of mothers and caretakers interviewed earlier, additional mothers and caretakers, and passersby (Figure 6).

In addition, an in-depth interview conducted by the design facilitators with a local carpenter provided insight into small-scale production issues, possible modifications to economize production, and demand and willingness to pay for the crafted items. Insight from the second field visit will be incorporated into the final designs proposed by the design facilitators, as the workshop's time frame did not allow for a second round of prototype iterations. In addition, there are crucial features for the final prototypes that must be addressed to qualify the designs for safe testing in the field.

Each of the three prototypes is presented below along with the feedback received during the community visit.

Figure 4. Interviewing mothers to gather information

Figure 5. Sketch models taken to the field visit

Figure 6. Prototyping and collecting feedback during the second community visit

3.1 PROTOTYPE #1: KELELA (SAFETY ZONE)

The group prompted with designing a DIY solution was highly influenced by the hexagonal plastic Chinese playpen shown during the workshop, abandoning their original DIY concepts to replicate the latter. Over the course of two days, the team constructed their own version of the Chinese model using polyvinyl chloride (PVC) tubes two cm in diameter, welded metal T joints at 120°, and umbrella fabric (Figure 7). The connector joints proved the most challenging aspect of the construction, and the team showed great ingenuity and resilience to find solutions. They first sewed a pocket joint, making all 16 before testing, and discovered that these did not provide adequate stability (Figure 8). They also devised

a PVC joint using a pipe bender, and eventually retreated to the college metal shop to craft and weld a joint.

The Kelela model is highly portable and can be easily assembled and disassembled, since the PVC structure can be detached from the metal joints, which slide into the tubes. To make the design more stable, the team used masking tape on the ends of the joints to make for a tighter fit within the PVC tubes.

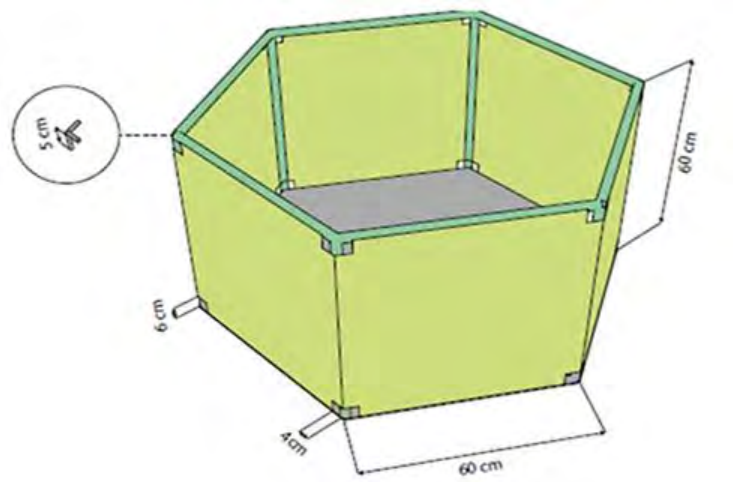

Figure 7. Specifications of the Kelela prototype

Each side of the hexagonal structure measures 60 x 60 cm and the play space offers enough area for one infant to play, although up to five older children gleefully piled in during the second field test. For improved cleanliness, the team placed an additional removable plastic mat (mintaf) over the flooring (Figure 9).

3.1.1 MATERIALS

- PVC pipe (2 cm diameter),
- Umbrella fabric,
- Plastic mat,
- Iron bars (1cm diameter), and
- Masking tape.

Material cost: 720 birr / 25.90 USD

3.1.2 FEEDBACK

Rural villagers indicated in the feedback visit that they liked the idea of having the product and enjoyed the prototype's portability. While some interviewees approved the playpen design as is, others suggested the material should be more colorful, and the frame could be stronger. Further suggestions included adding a mosquito net to protect children from flies, making the playpen wider to fit more than one child, and adding windows to provide visual contact between the caretaker and child as well as between child and external environment. The latter suggestion is, in fact, a safety and developmental requirement. Others noted that although the plastic mat layer is easy to clean, foam would be more comfortable for the child. From a child safety perspective, further iterations of the design should also consider the fabric openings on the lower junction points of the structure since these allow access to the dirt or the floor outside the playpen.

Potential users indicated that they would be willing to pay 250 to 350 birr for the Kelela prototype, while other interviewees expressed they would rather make it themselves out of local materials.

The Kelela prototype does not fit the DIY prompt given at the beginning of the design process, since it relies on welded joints, machine stitched siding, and slightly less accessible materials like PVC pipes. However, as the manufacturing directive was not a fixed rule but a suggestion, once the teams got into their work rhythm and expressed their arguments for the designs they chose, the facilitators supported them to follow their concepts. Unfortunately, the team sent their design for tailoring without review, which resulted in solid walls not meeting safety standards designated by experts in the information-

gathering phase of the workshop. Building in a team review process before production could avoid such situations.

Figure 8. Tarp joint produced in the first iteration. Later substituted for welded metal joint

Figure 9. Details of prototype #1 built by participants at the TVET workshop

3.2 PROTOTYPE #2: TESFA YEHETSANAT MAKOYA MAMRECHA (HOPE: MANUFACTURED SPACE FOR YOUNG ONES)

This team aimed to create a playpen that could be produced by local craftsmen at a local level. They built a portable bamboo prototype, in which two rectangular frames measuring 125 x 70 cm connect via four 125 cm horizontal bars at each edge, to form a square base (Figure 10). The bamboo used measures approximately 4.5 cm in diameter. The team made joints with simple holes drilled to size on the bamboo pieces. They connected sides and flooring as one piece, with walls made of mosquito netting and flooring made from a plasticized burlap tarp material (shara), topped with cushioning foam and a cotton fabric topping. The interior mounts to the bamboo frame by a combination of knots on the edges, and tarp channels stitched to the netting for the single bamboo bars to pass through. Foam padding secured to the rectangular bamboo frames with sewing thread offers protection from the hard bamboo surface and possible splinters. The team assumed a cotton sheeting of locally available fabrics would top the mattress for easier cleaning (Figure 11).

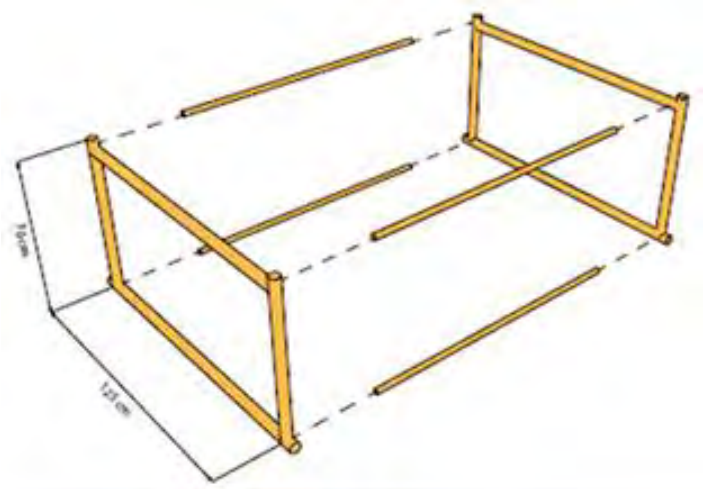

Figure 10. Assembly method of the Tesfa prototype

Figure 11. Details of prototype #2 built by participants at the TVET workshop

3.2.1 MATERIALS

- Bamboo rods (approx. 4.5 cm),
- Foam (5 mm thick),
- Plastic tarp (shara),
- Mosquito net, and
- Sewing thread.

Material cost: 420 birr / 15.10 USD

3.2.2 FEEDBACK

Community members appreciated the design, specifically the local materials and ease of production, portability, breathability, and size of the playpen.

One major concern expressed by both community members and participants was that USAID commonly issues mosquito nets in Ethiopia, and they should not be used other than for their intended purposes. In addition, the nets are not durable and rip easily depending on use. Interviewees praised the transparency provided by the net and feedback showed the net provided great visual range for caretakers and child.

As with Prototype #1, some interviewees indicated they would be willing to pay around 250 birr for the product, while others said that they would rather reproduce the model at home using nails and wood. In this case, they said they were willing to sacrifice portability for buildability. They also suggested using wood over bamboo since it can be sourced for free in most rural communities.

Other suggestions from community members included building a wider space to fit multiple children and adding a cover for flies. This model was the only one not field tested with removable flooring, although the team had in mind that a final proposal would include removable traditional fabric sheets in the playpen for cleaning. Nevertheless, community members suggested a removable floor during the community visit. While the foam covering addressed one set of comfort and safety concerns, the foam is not easily cleanable and could present a hygiene challenge.

3.3 PROTOTYPE #3: EYADERE'S YEHETSANAT MAKOYA MAMRECHA (EYADERE'S PLAY ZONE - NAMED AFTER ONE OF THE TODDLER PARTICIPANTS)

The third prototype was intended for large-scale manufacturing. The team designed a square playpen with sides 125 cm in length and 85 cm in height (Figure 12). The structure consisted of PVC pipes (2 cm in diameter). Like the Kelela model (Prototype #1), prototype #3 used welded T joints (90°) to connect the pipe. This model has walls fabricated from plastic-coated burlap tarp (shara) with mosquito net windows measuring 38 x 47 cm, which are sewn into three of the sides. The fourth wall has a flap of approximately the same size that serves as a door for children to enter and leave the playpen independently. As an additional feature, the team also produced a thin removeable mattress with foam covered by black plastic sheet that can be easily cleaned (Figure 13).

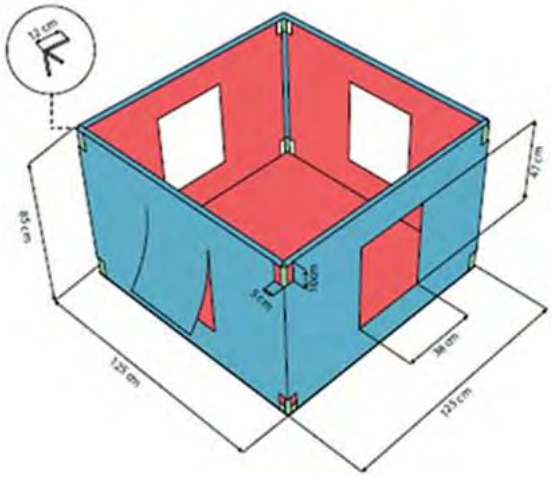

Figure 12. Specifications of the Eyadere prototype

3.3.1 MATERIALS

- PVC pipe (2 cm diameter),
- Plastic tarp (shara),
- Mosquito net,
- Iron bars (1 cm diameter),
- Masking tape,
- Foam (5 mm thick), and
- Black plastic sheet.

Material cost: 803 birr / 27.90 USD

3.3.2 FEEDBACK

Overall, interviewees liked the prototype, considered it appropriate for children aged 6-24 months, and demonstrated willingness to purchase. Interviewees also praised the playpen's portability which allows it to be used both inside and outside the home.

Some individuals interviewed during the field test visit expressed concerns that the plastic tarp might tear and requested more attractive colors. Community feedback also indicated satisfaction with the size (both height and width) of the playpen. On the other hand, the playpen's height can be an impediment to appropriate cleaning of the playpen floor, and most importantly, to comfortably placing and picking up the baby from its interior. Another suggestion was to use bed sheets rather than plastic, allowing for easier laundering with the family's regular bedsheets rather than generating an additional chore for caretakers to scrub and wipe the plastic down.

Figure 13. Details of prototype #3 built by participants at the TVET workshop

Community members provided feedback that the door was valuable because it allowed children to access the playpen by themselves rather than needing to be placed in it by caretakers. Independence seemed to be highly valued in this sense. The team noticed that when caretakers lured children into the playpen rather than placing them inside it, they were less upset about being away from their caretakers. Moreover, as other, older children often watch infants in a family, doors can be a useful accessory for older children who may not be able to comfortably lift an infant over the playpen wall. The team did not have enough time to devise a locking mechanism for the door, such a zipper or buttons and this was recognized as inadequate, and a necessary improvement in further iterations.

From a child safety effectiveness perspective, the openings in the fabric on the joint sections are problematic in that they permit children to stick their hands out onto the dirt outside the playpen. Also, the height of the tarp below the door needs to be considered, as it currently prevents dirt from entering but is a tripping hazard.

3.4 ADDITIONAL PROTOTYPE: POLYETHYLENE TEREPHTHALATE (PET) BOTTLE SIDE WALLS

Figure 14. Initial PET bottle wall mode (right); second iteration with horizontal bars on top/bottom for added stability (left)

During the prototyping phase, the design facilitators added an additional prototype to test the viability of reutilizing PET bottles building play spaces (Figure 14). The objective of this exercise was to examine the using materials that the working groups had not considered. They chose PET bottles for their wide availability, relatively low cost, and versatility. The groups constructed a few variations and concluded that the best option consisted of a rigid bamboo frame connected via holes drilled to size and fixed horizontal bars threaded through 500 ml PET bottles.

3.4.1 MATERIALS

- Bamboo rods (size depends upon final application, TBD)
- Recycled PET water bottles, half liter size (number depends upon final application, TBD)

Material cost: TBD, depending upon application
1birr / .03 cents per used bottle

About 60 birr 2 USD/ full size side (larger than pictured)

3.4.2 FEEDBACK

The advantages of this design include the use of readily available material, the relative transparency of the walls for infants to interact with their surroundings, and the possibility of engaging with the walls themselves for play. The bottoms of the water bottles were cut off to fit over the horizontal bars and could therefore rotate. This resulted in a freely moving, yet stable structure that provides visual and sound stimuli.

The toddlers present at the workshop primarily tested this prototype and appeared to enjoy playing with the bottles, especially the 16-month-old (Figure 15). We noticed that this type of structure needs to be especially stable since it invites children to play and engage with the structure, exerting more force than on a regular playpen wall. In addition, the team also noted that the gaps between the horizontal bars must be such that they impede the child from touching the ground outside the playpen. The bar closest to the ground should be as close to base as possible to prevent small hands from sliding beneath it.

One comment heard from a TVET instructor was that among the solutions presented, using water bottles for the walls was possibly the most cost-effective option, even considering that discarded PET bottles have monetary value in Ethiopia.

Figure 15. Sixteen-month old playing with and testing the first iteration of the PET bottle sidewall

4. FURTHER CONSIDERATIONS

4.1 STABILITY

One of the main challenges in building prototypes of the safe play spaces was building a structure stable enough to allow infants to support themselves on the frame and stand up. This resulted in the development of different joint designs (Figure 16). Two groups selected the metal joints. However, those joints can also be made by simply heating PVC pipes and molding them to the required angle. In addition, PET bottles that can be heated and shrink-wrapped to make a joint are also locally available. More extensive searching may identify readily available piping and joints for 90° angles, although it is doubtful that materials for the 120°angle required for the hexagonal design are readily available. Groups did not test wooden joint designs, but wood could also be an appropriate, affordable, and local alternative.

Figure 16. Different joints tested during the workshop

4.2 WALL FABRICS

Fabric alternatives might also be considered to reduce the cost of designs and/or allow for more local fabrication. Woven bamboo matting, rope net, or plastic burlap found in sacks across Ethiopia all provide low-cost alternatives. The umbrella fabric used in one design is quite costly. For a large-scale manufacturing design, the cloth used to produce scarfs, or the even more resistant transparent plastics could be a good option for increasing the lifetime of the product.

4.3 FLOORING MATERIAL

The floor of the playpen, according to safety requirements and practice, should be comfortable and easy to clean. It should fit the dimensions of the base and assure strangulation and suffocation are not a risk. Each group decided to work with plastic materials found in local markets. The large-scale manufacturing group chose black plastic to cover the foam. This option, however, is not ideal, as the plastic heats up in the sun and could prove uncomfortable or even harmful to the child. An alternative could be a light washable cloth or another type of plastic or rubber floor that does not radiate heat.

4.4 SHAPE AND SIZE

The size of the safe space should be further validated with the community. A smaller size can be more easily accommodated indoors, and more portable and cheaper to produce; however, it restricts use by multiple children and constrains exploration for a single child. Although the square or rectangle is the easiest to build, and uses less materials (therefore reducing costs), it could have unsafe aspects, such as the pointed edges and types of joints, for instance wires or nails. One option considered by one group during the sketch modelling phase was the circular playpen (Figure 17). The team pivoted to a hexagonal shaped design after the presentation of a Chinese model. It would be interesting to check how and with what type of materials they planned to build it.

Figure 17. Sketch model of a circular playpen

4.5 MOBILITY/TRANSPORTABILITY

During the brainstorming and sketch modelling phase, the groups also considered playpen portability. One of the groups proposed a playpen design with wheels. This option was not selected due to concerns from the design group and community regarding instability and risk of movement. However, this idea could be explored and considered by adding a wheel locking system to solve the problems presented by the participants.

4.6 ELEVATION

Some groups considered elevating the safe space from the floor. During the sketch modelling phase, one group designed a suspended floor to prevent the child from having contact with the ground. Another suggested stretching animal hide (quite common flooring in that part of Ethiopia) strung trampoline-style across the base, but realized that it would be too difficult and risky to create the necessary tension with fabric and string. With elevation, the frame of the floor becomes soft which makes it difficult for the child to stand. A strong frame, such as a wood hardboard, could be an alternative to design a safe space with elevation, although it might increase the final price of the product.

4.7 VIABILITY

As proven during the workshop, it is possible to build a safe space using local resources and local labor, which has many advantages: reduced cost, use of local resources, income generation, fomenting of the local economy, and use of specialized local labor, etc. Sometimes though, the use of local materials can be costly or challenging to build. In those cases, importing or mass producing some key materials (i.e., joints, fabrics, nets) might be a feasible option to reduce costs and simplify production processes.

5. NEXT STEPS

The three designs will be further refined for cost and safety considerations and vetted with child development and manufacturing experts. From these, two final designs will be produced on a small scale, each with distinguishing attributes such as type of floor, matting, net covering, door, etc. They will be tested together with the Chinese hexagon model in a home trial (TIPS). These home trials will monitor use (including duration and safety), attributes of the various models (such as shape, size, doors, wall/floor and mat materials, portability vs. stability, etc.), and general appeal of using the safe space by both infants and caregivers.

ANNEX 1: WORKSHOP AGENDA

	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed
	8/22	8/23	8/24	8/25	8/26	8/27	8/28	8/29
09:00-09:15	Morning circle	Morning circle	Morning circle	Morning circle		Morning circle	Morning circle	Morning circle
09:15-9:45	Design process presentation + Teamwork	Deep-dive into the problem	Narrow down: Top 3 ideas	Aggregating feedback		Sourcing materials	Group feedback	Filtering and considering the feedbacks
09:45-10:30		Empathy + interviews OAT		Caracteristics activity Design requirements & user needs		Building prototype	Adding requirements and standards	Prototype final details
10:30-10:45	Break	Break	Break	Break		Break	Break	Break
10:45-12:00	Problem awareness activity + Teamwork	Debrief + Active learning	Sketch modeling	Remind the requirements + Present some play spaces products	Break - Sunday	Building prototype	Improving prototype	How to sell
12:00-13:00	Lunch	Lunch	Lunch	Lunch		Lunch	Lunch	Lunch
13:00-14:00	Mapping ideals	Warming-up brainstorming	Sketch modeling	Choose Top 1 idea		Building prototype	Improving prototype	DEMO & Sales Fair!
14:00-15:00	Team selection	Ideation	How to give and receive feedback	Build-its - How to use tools				
15:00-15:15	Break	Break	Break	Break		Break	Break	Break
15:15-17:00	Team building	Segregating the ideas	Pitching + sharing + Co-creation	Build-its - Practice		Street feedback & testing	Street feedback & testing	Reflections & Defriefs + Next steps
17:00 - 17:15	Reflections & Debriefs	Reflections & Debriefs	Reflections & Debriefs	Reflections & Debriefs		Reflections & Debriefs	Reflections & Debriefs	Farewell gathering
17:15 - 17:45	Staff meeting	Staff meeting	Staff meeting	Staff meeting		Staff meeting	Staff meeting	Staff meeting
Deliverables	HW: Interviews	HW: more ideas	HW:Feedback	HW: Creative thinking		HW: Prototyping Feedback	HW: UX (User experience feedback	

Legend

Hands-on
Workshop
Action learning
Staff meeting

ANNEX 2: ADDITIONAL PHOTOS

Figure 18. Day 1: Introducing the design process and understanding the problem

Figure 19. Day 2: (clockwise from top left) the banana challenge activity exemplifies the design process through a hands-on activity (top right), generating ideas through brainstorming and presenting ideas using sketch models (bottom)

Figure 20. Day 3: (clockwise from top left) further work on sketch models, receiving feedback on designs from community members on the first field visit and the sketch models taken to Bahir Dar Zuria during the community visit

Figure 21. Day 4: Building and analyzing the mass-produced Chinese playpen collaboratively, and introductory session on how to use the workshop and power tools safely

Figure 22. Day 5: Prototyping design concepts to scale at the TVET workshop

Figure 23. Day 6: Finalizing prototypes to be taken to Bahir Dar Zuria on the second community visit and Day 7: Assembling the prototype in the field visit; testing and collecting feedback from community members

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