Exploring Co-design with Breastfeeding Mothers

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ABSTRACT

Designing mobile applications for breastfeeding mothers can be challenging; creating spaces to foster co-design – when a mother's primary focus is on her child rather than on design activities - is even more so. In this paper we discuss the development of the Milk Matters mobile application, a tool developed to motivate women to donate their surplus breast milk to the local milk bank. We look at the importance of different approaches to understanding the mothers, comparing workshops, surveys, and cultural probes. Through our work we identify three factors to consider when co-designing with and for mothers: 1) interrupted interactions 2) elements that might distract a baby and 3) the importance of empowering mothers through positive reinforcement. Based on these factors we examine our methodological approaches, suggesting ways to make future research with breastfeeding mothers more productive.

Author Keywords

breastfeeding; breast milk donation; mobile applications; co-design; cultural probes; user-centred design.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

Mothers of small children interact with computers in distinctive ways and although there are many existing applications and platforms for mothers, there has been little research into how to design for this user population. Developing a successful information and communication technology (ICT) intervention for mothers requires an intimate knowledge and understanding of their behaviours, feelings, the issues they face and their usage of technology, even more so if we want to ensure engagement with and sustained use of the intervention. We used a co-design approach to acquire this knowledge. We believe it provided

us with an insight not only into how mothers of small children interact with computers but an understanding of how to collaboratively work with these users in the formulation and solution of a problem.

In this study we worked with Milk Matters, a human milk bank situated in Cape Town [12], and their respective donor mothers. In working with this population we researched both how to design for mothers who are milk donors, as well as how to design for mothers with small children. Presently there is very little research on motivation for donating breast milk. We think co-design was a good approach to understand what motivates mothers to become donors and to continue donating their milk, and whether ICTs may contribute to increased or sustained donation. By using co-design we aimed to identify deterring factors in the milk donation process, understand the current practices and motivations of the Milk Matter donor mothers, how they interact with the milk bank and how Milk Matters manages their relationship with their donors.

Co-designing with breastfeeding mothers, when their primary focus is on their child, can be challenging. In this paper we discuss our experience of developing an application with breastfeeding mothers, an application meant to motivate these mothers to donate their surplus breast milk to the local milk bank. We compare the use of different methodological approaches to get an understanding of the mothers, how they use ICTs, and how to co-design with them. This research was done in three stages, using a different approach in each stage, namely a workshop, surveys and then cultural probes. Through our work we identify three factors to consider when co-designing with and for mothers: 1) interrupted interactions 2) elements that might distract a baby and 3) the importance of empowering mothers through positive reinforcement.

BACKGROUND

The Importance of Human Breast Milk and Milk Banking

Human breast milk has vital nutritional and immunological properties that cannot be replicated in infant formula (manufactured food for babies) [30]. As such, the use of human breast milk in an infant's diet results in positive health outcomes [29]. This is especially true for fragile infants [27], such as sick or premature infants in Neonatal Intensive Care Units (NICUs), whose immune systems may be weak. In addition, formula or alternate forms of food may result in health complications for some infants, such as

those whose bodies cannot tolerate it [30]. For these reasons human milk is considered to be a vital medical resource and the ideal source of food for infants, as stipulated by the World Health Organisation [1,30].

Milk banks play a very important role in collecting, screening and distributing human milk to the premature population. In this regard, the services provided by milk banks could be considered "preventative medicine" [22], as they provide the infant with many positive health outcomes [21]. However, the resources needed to ensure the milk is safe for consumption can be costly and are not available globally.

In countries such as Brazil, where donor milk banking is protected, promoted, and supported as an extension of national breastfeeding policies, milk banking has been incorporated into the health care delivery agenda for infants and children [13,16,35]. Other countries, such as France, Germany, Canada, Great Britain and Scandinavian countries, have made milk banking a national public health policy, and the service is covered by their national health insurance plan. However, in countries such as the United States, the growth of donor milk banking services has been neglected and no public health policy supporting donor milk banking has been made. As a result, mothers tend to rely on peer-to-peer milk sharing, which is more risky and costly [1].

Milk Matters
Milk Matters is a non-profit human milk bank that operates in the Western Cape, South Africa [12]. The milk bank is run by five women whose primary activities include sourcing human breast milk from donor mothers, pasteurising the milk for safe consumption, and distributing the breast milk to sick or preterm infants in local NICUs. The staff of Milk Matters comprises a dietician, a nurse, a lactation consultant and public health experts who have worked with breastfeeding mothers extensively. Most of Milk Matters' present interaction with donor mothers takes the form of emails (they have a mailing list consisting of 1016 donors, supporters and the general public who subscribe via their website), both automated and personal. This makes sourcing and attaining donor mothers and their excess breast milk a labour-intensive task, especially for a small non-governmental organisation like Milk Matters. At any one time they receive milk from an average of 20 women.

Breast Milk Donation
In order to become a donor, a mother has to undergo a rigorous screening process, which includes completing a health-related form, and submitting to a Human Immunodeficiency Virus (HIV) test and a Hepatitis B blood test, repeated every six months. Once the mother is a registered donor she has to collect jars in which to store the milk she expresses for donation from one of the Milk Matters depots. The mother is also required to make a large initial deposit of breast milk, partially to justify the milk

bank's expense of screening that mother. Once she has taken the time and energy to express milk for donation, she then also has to drop the milk off at one of the 24 depot locations situated in the Western Cape.

This is a demanding process that may deter many mothers from becoming donors and continuing to donate [18,29] especially considering the existing constraints on mothers' resources.

Once the first three litres of milk have been received, Milk Matters will send an email, detailing the quantity of milk donated and an estimate of the number of babies saved, to the mother to thank her for the donation. Communication after that is mostly news and events shared via the Milk Matters mailing list or Facebook page.

However, mothers tend to stop donating their milk after four or five months. Donors become frustrated and discouraged by the lack of feedback. Not only is the screening and collection process onerous, but since Milk Matters is unable to give immediate feedback on receipt, mothers feel that their donations are not as important as they really are. In order to overcome the difficulties and issues associated with donating breast milk to a human milk bank, it is clear that mothers need significant motivation to both start and continue donating, be it altruistic or otherwise.

RELATED WORK

Applications Designed for Mothers
Several projects have researched the use of ICTs to support, engage and empower women during the early stages of motherhood. For instance, Balaam et al. [8,25] developed Feedfinder, an application designed to support mothers who want to breastfeed in public but are anxious about doing so. They used an iterative user-centred design process where mothers were involved in the design and evaluation of the application. Interviews and workshop research methods were used during the design phase, and walkthrough and think-aloud methods were used to evaluate the Feedfinder prototype.

At the end of the study they discovered that it was challenging to co-design a technological artefact with mothers of young children, because the mothers' attention is divided between the unpredictable demands of their child and the design task. The study suggests that research methods used to co-design with mothers of young children should flexible, quick and undemanding, to ensure that mothers are able to remain fully involved in the design process.

The transition phase to motherhood has provided many avenues for research and development [24,25]. ICTs have been designed to provide pre- and postnatal support, social connection and information. Projects like the "memory stone" [11] look at supplying pregnant women with a tool to collect and review clinical and personal information from

their healthcare providers. Other projects, like MammiBelli [28], address expectant mothers' desire to share this kind of information with their intimate social groups. Kosaka et al. [20] created Mommy Tummy, which is able to simulate the experience of being pregnant and allow others to feel the mother's sensations.

ICTs have been designed to support the care of premature babies during the transition from hospital to home [10]. Furthermore, ICTs such as BabySteps [17], developed by Kientz et al., have been developed to support the child's early years, with regards to creating memories, keeping health records and using the ICT to communicate this information with family and health care professionals.

There are many existing applications created to support new mothers with things including, but not limited to, pregnancy tracking (babycentre.co.uk), sleep and baby monitoring (tmsoft.com/white-noise-baby), recording baby milestones (todaysparent.com), recording growth (growthapp.net), and tracking nursing (sevenlogics.com/mobile-apps/baby-nursing-app).

Co-designing with Mothers
Many different approaches have been used in projects that involve co-designing with mothers. Hui and Neustaedter [28] used semi-structured interviews during the design process of MammiBelli. With only ten participants this approach was successful in maximizing the amount of feedback they got from each participant, specifically as each mother's experience is unique to their situation, as it is in our project.

Other projects that required mother-generated innovation and ideas preferred to use brainstorming workshops. For instance, D'Ignazio et.al. [4] ran a workshop with a group of mothers and experts to find potential solutions to problems facing breast pump users during postpartum period. The workshop demonstrated how much interest there was in their problem and the need for a large-scale conversation on the topic. They pointed out that their approach may not fit all maternal-related topics, but it worked well with their feminist Human Computer Interaction (HCI) method of participation where they used crowdsourcing to gather more ideas via email and social networking sites.

Gibson and Hanson [23] also made use of workshops in their research. They recruited participant mothers by advertising 'special guest' attendance at each meeting, with limited success. The researcher, who was a new mother herself, brought her child to each workshop and was able to identify with the participants based on the shared experience of pregnancy, childbirth and motherhood. However the presence of small children required deviations from normal workshop practice, such as nappy-changing breaks that halted the session, but were valuable and allowed the researched to consolidate her notes. We experienced similar disruptions while co-designing the Milk

Matters application, and adjusted our research approach accordingly as the project progressed.

Morris [31] and D'Ignazio et al. [4] employed online surveys to gather a broader range of diverse feedback from more participants where a workshop would not suffice. Both these projects' surveys were advertised online via social networking sites and email. Morris offered an incentive for participation and found that the majority of her participants (34.2%) learnt about the research from paid-for promotional posts on BabyCenter (babycenter.com). Morris and D'Ignazio et al. received a large amount of feedback using this approach. However D'Ignazio et al. noted that analysing so much data proved to be resource-costly and took up more time then expected.

Westerland et al. [3] acknowledge that there are many different ways to approach research involving mothers and family units. They used triangulation [42] in their work, an approach that involves a combination of methods to obtain different results. Notably they made use of cultural probes, workshopping, observations, interviews and prototyping, much like the project in this paper. The use of cultural probes encouraged their participants to be innovative and successfully included the whole family unit by giving each member different activities suited to their maturity. Although the probes took a long time to yield results that may not have provided any specific design ideas, they were useful to frame the design space, subsequent activities and prompt discussion in further workshops and interviews.

Motivation to Donate Breast Milk
Studies have found that milk donors are motivated by an altruistic desire to help somebody and that they feel they have a social responsibility to donate their excess breast milk [30]. In the case of donations to human milk banks, donor mothers are frequently motivated by their knowledge of a particular infant's need for human breast milk. Other mothers are motivated by the hope that somebody else would do the same for them if their own children were in need of human breast milk [18].

Mothers consider their breast milk to be a valuable resource, as they are aware of its nutritional properties and ability to sustain life. Furthermore, mothers who express milk for their own, or other peoples' children invest significant time and energy into doing so, which adds to their perceived value of their milk [30]. As such, many mothers who have an excess supply of breast milk do not want to waste what they consider to be a precious resource. These mothers would like to know that their milk benefits a sufficiently needy and deserving recipient [18].

There appears to be little in the literature pertaining to the use of mobile technology to motivate and facilitate the donation of breast milk to human milk banks. However, there is research into the use of mobile applications to facilitate and promote blood donation [5,36,37,41]. ICTs have played an increasing role in providing additional

motivation, support and feedback for blood donors. Ishema [34] describes the impact of a mobile application that enabled blood donors to receive news and notifications. Foth et al. [26] employed a combination of mobile application technology and social media in order to enhance the loyalty rates of young blood donors. In our application, we include similar features to those listed in blood donation applications.

APPROACH TO CO-DESIGN WITH BREASTFEEDING MOTHERS

Co-design is an approach that fosters collective creativity amongst participants of varying levels of expertise throughout a design process [7]. Co-design promotes an equal relationship between the end users and designer, inducing a shared sense of ownership for and the sustainability of an artefact [6,15,32]. These ideals were pivotal in the choice of our methodology, specifically when deciding what would give the mothers the most freedom to express their ideas, thoughts and opinions. This approach was used to confirm our commitment to feminist HCI practice, which has similar values such as agency, fulfilment, equity, inclusivity, empowerment, diversity and social justice [39]. As researchers this meant having an empathetic relationship with the mothers, sharing information about ourselves with them, and then reflecting on our actions and results in each stage of the research [38].

We approached this project two different ways. Initially, we took a very rapid approach, with short iterative cycles, focussing on developing and deploying the Milk Matters application within a year. After evaluating the application during its deployment we took a more deliberated, explorative approach with a longer time frame. To deliver meaningful additional features in the application after its deployment in the initial stages, we wanted to get a better understanding of the Milk Matter donor mothers before going forward with further development.

In stage one and two our rapid co-design approach consisted of a design, prototype, and evaluate cycle. Each iteration of the cycle resulted in a higher-fidelity prototype than the last. The first iteration of stage one produced a low-fidelity paper prototype. The second iteration produced a working mobile application, with all of the core functionality implemented. Stage two resulted in a refined mobile application, with the remaining features and functionality completed. This was evaluated using an online survey.

In stage three, we took a more deliberated approach to get a more intimate understanding of both Milk Matters and their donor mothers. We chose to use participant observation to research Milk Matters, see how they interact with their donors and what kind of impact the donated breast milk has in the NICU.

Thereafter we gave the participating donor mothers (recruited by Milk Matters from their existing donor mother contacts, using email and phone calls) probe packages. The cultural probes were used to gain further understanding of the breastfeeding mothers and who they are as users of our mobile application.

Stage One

Initial Meeting with Milk Matters
In an initial meeting with two Milk Matters staff members, we identified needs and requirements that they had for the mobile application, which would allow them to engage with their donors. We also asked about their organisational activities, operations, and constraints.

Brainstorming and Prototyping Workshop
After the initial meeting with Milk Matters, we arranged a two hour brainstorming and paper prototyping workshop, held at the first authors' flat with Milk Matters donor mothers. An invitation was sent to eight of the current donors, of which two could attend. The workshop, combined with the initial survey described below, comprised the first iteration of the design, prototype, and evaluate cycle. The aim of the workshop was to gain an understanding of what donor mothers would need from and value in such an application, and to get feedback on the paper prototypes we had designed, based on the information attained in the initial meeting with Milk Matters.

Initially we encouraged the mothers to share their experiences as breast milk donors with Milk Matters. Once we had a general understanding of their experiences and background, we conducted the brainstorming component of the workshop. In this brainstorming session, the mothers were prompted to share what they would require of such an application; what would be valuable and useful or not be appropriate in such an application; what would motivate them to donate; would improve their experiences as breast milk donors; and would improve their interactions with Milk Matters.

The mothers were then asked to rank the features and functionality they had identified in order of importance. Following the brainstorming component of the session, we introduced the mothers to the proposed features and functionality we had identified in the initial meeting with Milk Matters, and showed them the resulting paper prototypes. At this stage in the design process, we had opted for low-fidelity paper prototypes. The disposable nature of these prototypes prevented us from overcommitting to any design, or deterring the mothers from critiquing them honestly and completely.
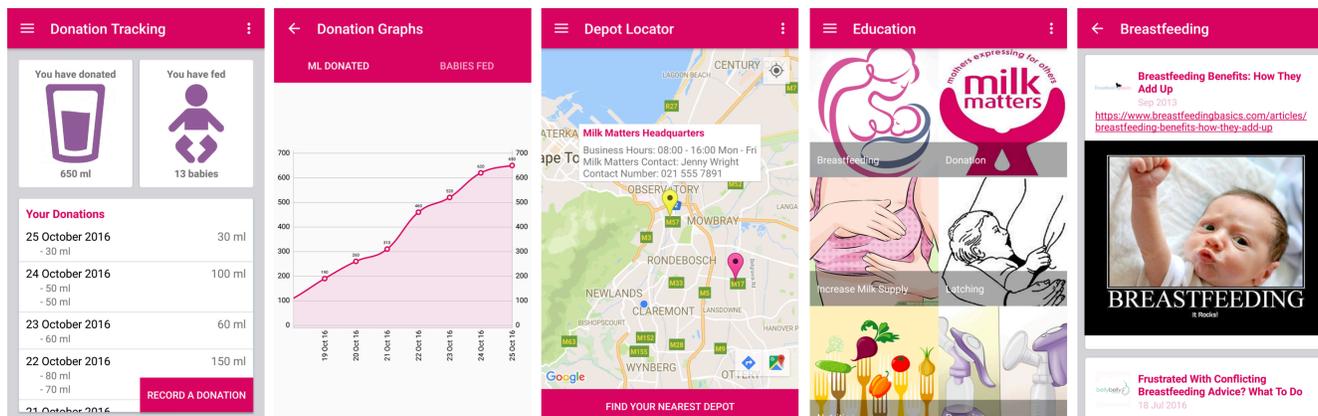
Figure 1: Milk Matters on Android, the donation tracking and visualization screen, the depot locator, the education topics screen, and breastfeeding topic screen

Initial Survey

Due to the difficulties experienced by mothers who were keen to participate, but were unable to attend the brainstorming session, we opted to distribute a survey enabling previous and present donor mothers to share their thoughts and opinions on what the Milk Matters mobile application ought to be.

Milk Matters distributed the survey via email to 1016 people on their mailing lists, of which 41 responded. The survey made use of both closed and open-ended questions to obtain both quantitative and qualitative data about mothers' preferences for the proposed functionality. Most of the questions asked mothers to respond using a 5-point Likert scale, in order to facilitate quantitative comparability between the mothers' responses for any particular question. Mothers were also given the option to comment freely on all components of the application, thereby allowing for qualitative feedback.

Follow-up Interviews

Having redesigned the application based on the feedback we received, we hosted follow-up interviews with the two donor mothers from the initial workshop. The aim of these interviews was to evaluate the second prototype, which took the form of a mostly complete mobile application. We opted to perform a cognitive walk-through with the mothers individually, so they would not be influenced by what the other was doing. Each user was required to complete certain tasks with the application, and encouraged to think aloud as they did so.

Following the cognitive walk-through, the mothers were asked a series of open-ended questions about their experience with and their perceptions of the application, as well as suggestions for further changes. This enabled us to attain a more complete evaluation of the application.

Stage Two

Follow-up Survey

The second redesign of the application produced our third, final, and highest-fidelity prototype: a complete application, ready to be used by mothers. A follow-up survey was distributed to the mothers as a means of evaluating the third prototype. The survey was accompanied by a link to the application on the Google Play Store [33], allowing mothers to test it before responding.

Application Deployment

The mobile application, co-designed and developed with Milk Matters and their donor mothers [33], was deployed to the Play store in November 2016, after a beta version had been deployed and tested for a month. As of November 2017, the application has had over 82 total installs, of which 29 are on devices active in the 30 days prior to writing.

Using the application (shown in Figure 1), donor mothers can record their milk donations over time. The application allows them to visualize the impact they have made regarding the number of babies fed with their contribution. This is intended to increase the motivation of the donor mothers.

Donor mothers can use the application to read articles on breastfeeding related topics; the application allows the mothers to educate themselves about latching, nutrition, pumping and increasing milk supply. This is intended to improve and aid their donation experience.

Donor mothers can use the application, via a Google maps plug-in with depot locations and relevant information, to navigate to the nearest depot and deliver their donated milk whenever and to whichever depot they want. This is intended to empower the donor mothers who previously would only go to the depot location assigned to them by the milk bank.

Potential donor mothers can use the application to complete a short quiz. This allows them to verify if they could become a donor before contacting the milk bank, which is intended to entertain and motivate interested mothers so they consider becoming a donor.

The application allows the milk bank to share news, events and additional contact information with their current and potential donor mothers.

Stage Three

Participant Observation

In the third stage of our project we chose to use participant observation so we could establish an in-depth relationship with our participants, in order to develop a deeper understanding of what they value in the current Milk Matters application and areas where we could improve it. We used this approach to get a better sense of the donor mothers' values, beliefs, daily routines, and struggles.

The first author began volunteering for Milk Matters in February 2017, working in their office for three hours once a week, collecting milk from mothers and depots, and delivering it to the milk bank. While collecting donor milk, she observed the donor mothers and how they interacted with the milk bank. While working in the Milk Matters office, the aim was to acquire knowledge on the milk bank, such as how much time they had available to manage our ICT intervention, what the bank's technical capapbilities were, and how the bank provided feedback and motivation to their donors.

Probe Packages Deployment

We used cultural probes to gain a better understanding of the donor mothers and to provoke thoughtful responses from them [2]. We wanted to use the collected probe packages to initiate further dialogue and brainstorming with the donor mothers.

During stage one we had found that it is often difficult to acquire intimate and reflective insights about users' behaviours, thoughts, cultures, attitudes, preferences, concerns and needs from common methodology [9]. Techniques such as questionnaires lack depth if the user is distracted from answering your questions thoughtfully, as most of our mothers were when they had their babies present. Probes are intended to encourage the user to look at and think about their environment in a new way [2,19]. We wanted to use probes to gain an insight into the lives of our breastfeeding mothers, which would help to identify unknown problems, highlight new opportunities, reveal design constraints and inspire a new way of thinking about design with them.

The probe packages included different activities and materials, meant to elicit different responses. We included three postcards with a question on each (what is something really good about donating milk; what do you wish was different with donation or Milk Matters; what is your relationship with other donor mothers) and a fourth containing an introductory biography of the first author. We used postcards to encourage the mothers to provide informal responses about their relationship with the milk bank and other donor mothers. We also wanted to introduce them to the researcher in a fun way.

The probe packages also included a booklet that had activities for the mothers to complete everyday for a month. The activities were two-fold: a daily log to capture how much and how often she expressed her milk and what mood her and her baby were in; fun activities to be completed over two days, which prompted the mothers to make observations and capture information about her daily experiences as mother and milk donor. The aim of the daily log was to establish how much of the mothers day was spent breastfeeding or expressing (for her baby or for Milk Matters). The aim of the activities was to find out about the mothers' social interactions, struggles and pursuits in a day. We included activities about mother's ICT use, such as what sites or online forums they were using, what information they were looking for and what kind of WhatsApp or Facebook groups they belonged to.

The participants could write/draw in the booklet, or send pictures, texts, voice notes or videos to the first author via WhatsApp. Stickers, colouring pens and post-it notes were included in the pack to help the mothers complete the booklet.

FINDINGS

Stage One Findings

Initial Meeting with Milk Matters

In the initial meeting with Milk Matters we came to a consensus about what should be included in the application. Together we produced a list of functional and non-functional requirements for the application.

Milk Matters also told us about the need for sensitivity around mothers when it comes to expressing breast milk: each mother produces milk at her own pace and should not be worried about quantities. We agreed that the application could be used to positively reinforce the donor mothers' emotions about their donation and capabilities as a mother.

Brainstorming and Prototyping Workshop

Organizing a workshop with the Milk Matters donors was challenging to do over email, their preferred mode of communication. We sent an initial email to eight of Milk Matters current donors proposing a workshop at 10AM on a Saturday morning. Two mothers responded, but said they would prefer to meet in the week as they were both stay-at-home moms and wanted to spend the weekend with their family.

During the workshop both mothers said they donated for altruistic reasons, and because they hoped that somebody would do the same for them and their babies. They indicated that they would appreciate more feedback and engagement from Milk Matters, but understood the bank was often short on time and resources.

Mothers stated that that they were particularly driven to donate by the testimonials, or "success stories", of children and mothers that have been helped, which are presently shared on Milk Matters' Facebook page. They shared how uncertain mothers can be about the amount of milk they are able to produce for their baby, *"you wonder is it enough to feed them, am I doing a good job"*. Both participants

emphasized how important it is for new mothers to get validation or positive reinforcement about their contribution, and that donation is one way to feel confident about their abilities.

The mothers agreed there was a need for some form of depot locator, as having to go constantly to the specific depot they were assigned to was a logistical issue. The mothers seemed particularly attracted to the prospect of being able to drop off their breast milk at their convenience: *"mothers are always out and about, and it would be nice to know if there is a depot close to you or where you are going for the day"*. They said it made them feel empowered, when so many of their daily choices were dictated by their babies. The mothers also requested that the depot locator display extra information about each depot, such as the opening hours, contact number, and Milk Matters contact person. This would prevent mothers from having to arrive at a depot and awkwardly enquire about who they ought to drop off their breast milk with: *"it would be nice to know who is at [that] clinic"*. The mothers felt that the donation process would be considerably more pleasant and personal if they could build rapport with these Milk Matters contacts, which the depot information might enable them to do.

During the paper prototyping section of the workshop the mothers identified various non-functional requirements which they deemed essential. For instance, the mothers stated that it was crucial for the application to be easy to use with one hand, as they often tend to use their phones whilst breastfeeding, or performing other tasks which left them with only one available hand.

The mothers identified an issue with the proposed education section, in that it was designed to include videos; the mothers stipulated that the application should contain no audio-based functionality, as they were concerned about disturbing their babies: *"watching videos can be noisy and too distracting for [a] baby"*.

Having both mothers present to discuss and brainstorm was helpful in generating ideas. By sharing their experiences as mothers and with Milk Matters they found that they had a lot in common, such as the parenting websites they refer to (bellybelly.com, breastfeedingbasics.com and kellymom.com), expressing times (usually between 1 and 5AM), wanting the application to have no distracting elements and be easy to navigate with one-hand. This created a relaxed atmosphere with flowing conversation, as the mothers added to what the other said in response to our questions.

Both mothers brought their babies along, which meant that the session was interrupted several times by crying or breastfeeding. However, by having more then one mother present, if one was attending to her baby the other was still focused.

Initial Survey

From previously reaching out to the donor mothers via email and seeing their willingness to participate online, but reluctance to attend a brainstorming workshop, we employed a different approach to get their feedback. We used an anonymous online survey, emailed to the 1016 users on the Milk Matters mailing list to see if their answers would reflect the opinions of the two donor mothers who attended the workshop.

Function	How useful would this be to you? 5 – Very useful	How much would this improve the donation experience? 5 – Vast improvement	How much would this motivate you to donate (more)? 5 – Very motivational
Depot Locator	Mean: 4.73 Mode: 5 SD: 0.51	Mean: 4.03 Mode: 4 SD: 0.86	Mean: 3.73 Mode: 4 SD: 1.14
Donation Tracking	Mean: 4.76 Mode: 5 SD: 0.98	Mean: 4.66 Mode: 5 SD: 0.89	Mean: 4.66 Mode: 5 SD: 0.96
Education	Mean: 4.41 Mode: 5 SD: 0.78	Mean: 3.88 Mode: 4 SD: 1	Mean: 3.37 Mode: 3 SD: 1.25
News and Announcements Feed	Mean: 4.12 Mode: 5 SD: 0.41	Mean: 4 Mode: 4 SD: 0.52	Mean: 4.1 Mode: 5 SD: 0.65

Table 1: Evaluation of proposed application features, answered by 41 donor mothers

The survey was answered by 41 mothers, who expressed similar views to the two interviewees (see Table 1). The most popular feature was the donation tracker, and a mother responded that adding this feature: *"would be awesome, I'd love this!"* and that *"Seeing how much you have donated and how many babies you have helped is an amazing motivator"*. The mothers also responded positively towards a news and announcements feed, stating that: *"it would be great to have a bit more real time info on where the milk is being used, and some little stories about the babies who are needing it"*. One mother said the depot locater would be: *"Empowering to be in control of deliveries"* and, as the donor mothers had mentioned in the workshop, this feature *"Can help busy moms coincide milk drop offs... with baby check ups"*. The education aspect received the lowest rating, but still found useful and motivating. One mother said: *"This would be great. Most moms are looking up resources all the time"*.

The limitation of this method compared to the workshop, was that the information was not as extensive. However, giving the mothers the option to answer the survey at any time, from anywhere, resulted in many more responses and by extension achieved its purpose of validating design decisions we had made previously.

Follow-up Interviews

We met with the same two donor mothers from the previous workshop for individual follow-up interviews. The

individual sessions were successful, even though we had to pause when the baby interrupted our interactions.

The most common difficulties the mothers experienced whilst completing the stipulated tasks during the cognitive walk-through of the application, were navigation related. One of the mothers had an iPhone and was confused by the Android User Interface, not by the Milk Matters application. Once the mothers located the side menu in the application, that took them to the appropriate screen/component for the completion of a given task, they were able to complete it with relative ease and without problems.

In general, the mothers were satisfied with the application, and felt that it met their expectations of what a Milk Matters mobile application ought to be. Both mothers felt that the user experience was consistent, intuitive and pleasing throughout the application, and that the application was likely be useful and to and motivate them to continue donating.

The selection of the materials used in the education section had been co-designed by mothers during the brainstorming workshop, based on sources they regularly used and trusted. Milk Matters confirmed that all of these were reputable and trusted parental websites, also used by the bank when adding content to their Facebook page and in answer to some donor mothers' specific questions. As such, the education content in this research was not designed specifically for the project, but rather taken from trusted sources that the mothers enjoy to read. The mothers' only suggestion was to add a suggestion button to the education section: *"mothers like to have their own say in this context"*. They felt this would make the content feel more peer-reviewed and relevant to their situation as donor mothers. They said this would also increase the likelihood of them sharing the content, and by extension the application, with their friends.

We had a final meeting with three Milk Matters staff to show them the completed application before deployment. They wanted to remove some of the depot location contact information that the donor mothers had requested, such as cell phone numbers, to ensure the privacy of the staff working there. Additionally there was some conflicting information in the education section, with which the milk bank disagreed (e.g. Fenugreek should be taken to increase milk production).

Stage Two Findings
To evaluate the deployed application we sent another online survey to the Milk Matters donor mothers. Only one mother responded, even though the application had had over 21 installs at the time.

Stage Three Findings
Participant Observation
In stage three the first author began volunteering at Milk Matters. We found that by volunteering at the milk bank on a weekly basis, it provided an opportunity for informal dialogue with the staff. A physical presence in their office also served as a reminder for them to recruit participants for the cultural probes, which they were willing to do because the first author was helping them with collections and office work in return.

Cultural Probes
Based on our experience with organizing a workshop for multiple donor mothers in stage one, we chose to use individual house visits with them instead, in stage three. This gave us a lot more flexibility to plan sessions, which we found was necessary as we had donors ask for sessions to be moved for bath time, a sick baby, a mother who had just gone back to work and needed to meet later in the evening or a mother who wanted to get her child to nap before we visited her.

The probe packages were left with three donor mothers for a month. We met each mother in her home at a convenient time. We found this setting more relaxed and could discuss their relationship with Milk Matters in a stress-free way, usually while sipping tea.

Two of the mothers had used the application prior to our meeting and the third had an iPhone. Both mothers responded positively towards it, liking it for different functionality. One mother said she loved being able to record her donations, it made her feel empowered and positive about herself. *"I like to see how many babies I've helped"*. The same mother had even taken the time to download the application onto her new phone and re-enter her accumulated data to continue using it. She said that besides donation, the recording function helped her keep track of how much milk she was expressing at a daily rate, for her own records.

Another mother said she loved the application because of the educational section. Unlike the first mother, who had been donating before the application came out, she downloaded it for the first time when she first became a donor. This coincided with her first child and having to breastfeed for the first time. She said she had relied on several of the articles in the educational section, such as the "increase your milk supply" articles, to help her as a mother and a donor. She said how concerned and anxious she felt about her supply and by reading those articles felt more confident in her abilities: *"this is exactly the issue many mothers face when they first start breastfeeding and will find this section very helpful"*.

At every session in stage three the mothers had their baby with them. We found this tended to interrupt our discussions, much as it had in stage one and two, especially with one mother who had three younger children all vying

for her attention. We appreciated the efforts the mothers made to continue working with us. If they were distracted by a child they gave him/her a toy to keep them busy, so she could focus on the session.

The probes confirmed much of what we had found in the previous stages. The mothers emphasized again how anxious they were about their breast milk production: *"How to get my body to make milk without relying on Fenugreek and Moringa tablets"* and *"I have been anxious about my supply, which makes my supply take a dip"*.

Being a donor seemed to increase the stress: one mother said she was worried that the supply of milk left for her baby while she was at work would run out because she had donated some of it. Yet the same mother said she had begun donating because she would have needed donated milk in the NICU, if her supply had not started. She was so anxious about her situation that she had resorted to calling Milk Matters, who told her she must always put her baby first.

All three mothers had hobbies to keep them relaxed, such as crocheting, dancing, gardening and reading: *"luckily reading while pumping adds as a good distraction and helps pass the time"*. They reiterated the need for activities that do not distract their baby, but keep them occupied while performing lengthy tasks such as nursing or pumping.

One of the probe activities was an 'archaeological dig' where the mothers had to describe or send us pictures of objects that relate to motherhood. One of the items described was a cell phone with the following: an extensive search history of baby and nursing related queries (baby's constipated, how to get rid of cradle cap, 6 month milestones, how young can a baby start teething?); mommy support groups such as the La Leche league (lalecheleague.org) and baby yoga; and WhatsApp contacts that are often relied on for support, such as family members, a lactation consultant, a doula, and mothers going through similar experiences.

DISCUSSION

The Life of a Breastfeeding Mother

In this research our target users are current donors and potential donors of breast milk, specifically mothers who are lactating and can donate excess breast milk to Milk Matters. In our stage one findings we learned that donors are motivated by a sense of altruism and positive feedback [18,29,34], but struggled with some logistical aspects of donating milk. The depot locator and donation tracker were designed to address some of these issues, giving mothers freedom to choose where to drop off milk, and immediate positive reinforcement of their donations.

At the same time, the process of requirement gathering also uncovered several other aspects of being a mother who uses an application. In this section we highlight our findings and suggestions for designing for mothers with small children.

Interrupted Interactions
Intermittent use should be accounted for when designing ICTs for mothers of small children. Our interviews, even when not in the mother's home were frequently interrupted by children. In the same way, mothers tend to put their phone down and pick it up again on a regular basis, as they alternate between doing tasks on the phone and attending to their children.

Single-handed Interaction
The mothers also said they often only have one-hand free when handling their phone and attending to their child. The mothers emphasized that they do enjoy using their phone for entertainment while completing routine, lengthy activities, such as pumping or breastfeeding. However as mentioned above, they only have one hand available to navigate their phone making it difficult to do precise complicated tasks on an application.

Elements that Might Distract a Baby
Mothers said that they did not want to open anything with loud noises or flashing displays when using their phones while their baby was present, as it would distract or excite their baby. This directed our decision to use articles for reading, rather than videos, in the Milk Matters application educational section. This was a preferred decision amongst the donor mothers.

Empowerment Through Feedback and Choice
We found that mothers like to express their views and opinions on what they feel is best for their child. They are eager to share their experiences and what they know about being a mother with other mothers. Similarly, we have found that mothers tend to learn a lot from advice given by others on social media channels, such as La Leche league, where the content is moderated for accuracy.

Mothers want to be in control of their own life, given that much of their decisions are taken away by having a child (such as when they get to sleep, what shows they can watch around the baby and activities they can do while caring for their child). We found that they responded to functionality that gave them control, such as the depot locator or the ability to record their own donations.

Positive Reinforcement When Contributing
It is acknowledged that mothers tend to have a lot of insecurities. New mothers in particular lack confidence about their ability to feed and care for their babies. It is important that the application supports mothers and reassures them that any contribution is positive, and it is natural for each mother to express milk at different rates.

Implications for Co-design

Co-designing with Mothers with Babies
When working with mothers it is important to be aware of how little time they have available. This impacts their availability to participate in workshops, focus groups or interviews. As Pedersen and Buur suggest [14], we

recommend research should be completed at the participants home or online, as travelling can be challenging for a mother with small children. Beyond having to finding the time to travel to a location (which is more difficult if they are working), there are also other considerations, such as packing a baby bag or finding a sitter, that make house visits more convenient for participants.

During sessions with mothers with small children, similar to Balaam et al. [8,25], we found that their babies can be very distracting, and we did not have their full attention, even in individual sessions. Additionally, a mother with a small child may only have a single hand available for sketching or prototyping. Discussion-type interviews may be more productive in this situation.

In the remainder of this subsection we consider our three approaches and how they worked for the mothers.

Workshops
The workshops resulted in useful feedback and the discussion prompted by shared experiences sparked conversations that might not have happened in a one-on-one situation. However, the workshops were difficult to schedule for more than two mothers, especially if they were working and had limited time available. For this population interviews may be preferable as they are easier to organize. It is also unclear if the mothers agreed on some issues because they were together and did not want to give their own opinions [19].

Surveys
Like Morris [31] and D'Ignazio et al. [4], we found that surveys work well with mothers who are unable to meet and prefer the option of responding remotely at any time. However responses are variable and may require further reminders, advertisements or incentives to obtain more responses. In this project we should have implemented usage logs to evaluate the application in-use instead of deploying a survey that only received one response.

Probes
There are two obstacles to this approach: it requires long-term deployment, which participants may not be willing to commit to; and the probe packages needed extensive planning as to what we wanted to achieve and how we could obtain that feedback. The data gathered from this method may provide interesting reflections on the users of a proposed technology, but lack focused design implications. However, probes are good for focusing future interactions and as a starting point to any design discussion [3,42].

Working with an NGO
As can be seen we were not able to meet with Milk Matters formally as often as we would have liked to because of their time constraints. Using participant observation was useful to get weekly updates and feedback from the Milk Matters staff.

We were very reliant on Milk Matters to contact their donor mothers before we did. This slowed down the pace of the project tremendously, especially when external circumstances prevented them from recruiting participants and we had to postpone activities.

From a design point we could not look at developing anything that required a lot of effort on their side because of the high rate of changeover in the Milk Matters staff and low technological skills.

Balancing Requirements Between Milk Matters and the Donor Mothers
During this research we saw several instances whereby what the donor mothers want in a given artefact differs from what the milk bank is willing to provide. In such situations we have had to measure what the impact of removing a function would have on the eventual use and effectiveness of the artefact [40]. In most conflicts we followed Milk Matters' wishes, as they will be the drivers behind the artefact in the long run.

CONCLUSION
In this paper we used a co-design approach to elicit the requirements and needed features for an application used by breastfeeding mothers. Design considerations included: 1) interrupted interactions 2) elements that might distract a baby and 3) the importance of empowering mothers through positive reinforcement. This approach has been especially important in this context, where the constraints of nursing young children affect how mothers interact with their phones and with Milk Matters, as well as their participation and availability for this project.

Thus far the mobile application has met the expectations of both Milk Matters and their donor mothers, based on the predominantly positive feedback we received. Co-design as an approach seeks to bring to the surface some of the design constraints and considerations that might be obvious to the end users (e.g. breastfeeding mothers), but would not be apparent to the average software designer or HCI researcher. These non-functional requirements can make the difference between applications with very little adoption and those that are actually taken up and used by the target population. While it is too soon to establish whether this approach has succeeded, our initial surveys and cultural probes indicate that we are on the right track.

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