Baby Steps: Evaluation of a System to Support Record-Keeping for Parents of Young Children

Julie A. Kientz
University of Washington
Technical Communication,
The Information School, and Dub Group
Seattle, Washington, USA
jkientz@u.washington.edu

Rosa I. Arriaga, Gregory D. Abowd
Georgia Institute of Technology
School of Interactive Computing and
Health Systems Institute
Atlanta, Georgia USA
{arriaga, abowd}@cc.gatech.edu

ABSTRACT
Parents of young children often want to keep a variety of records on their children's early years, for the purposes of preservation of memories or at the request of their pediatrician. However, time constraints, motivation, and forgetfulness may hinder their ability to keep consistent records. We developed a system, Baby Steps, which is designed to improve the record-keeping process. In this paper, we present the results of a 3-month deployment study of this technology with 8 families and their pediatricians. The study showed that when compared to a control condition, experimental design features of Baby Steps encouraged parents to more frequently collect and review records, provided higher confidence in reporting, and improved parent-pediatrician communication.

Author Keywords
Children, health, families, decision support, developmental delay, real-world deployment, field trial

ACM Classification Keywords
H5.m. Information interfaces and presentation (*e.g.*, HCI): Miscellaneous.

INTRODUCTION
Becoming a new parent is often a life changing, enjoyable experience. Many new parents have dreams for their newborns and want to raise the child to the best of their ability. Parents often want to record information on their child as they develop, such as their physical characteristics, favorite foods and toys, and pictures and videos that provide snapshots of their child's life. Reasons for this may include wanting a record for their own personal reflection, to share with family and friends, or so their child can someday in the future see how they were as a young child.

In addition to wanting to keep records for personal or sentimental reasons, many pediatricians and public health organizations, such as the Centers for Disease Control, encourage parents to regularly record their child's developmental progress to help assess the risk of developmental delay. As a result, pediatricians often provide parents with development assessment surveys to complete over the course of several months between visits during their first five years of life. Detecting and treating these delays and disorders early is often the key to ensuring a healthy outcome of the child [22].

Previously, we conducted an in-depth qualitative study identifying the requirements for record-keeping for parents [16], where we found that despite the need and desire to record information on young children, there are still many challenges that parents face in collecting enough quality information. Raising a child can require much effort on top of an already hectic lifestyle, and lack of time may be a reason why parents do not record as much information as they would like. Traditional methods of recording information are often not proactive, and parents forget to regularly write data in a baby book or diary. There may also be psychological or cultural factors that prevent a parent from regularly recording developmental information for their pediatricians, such as a fear that their child is below average or a desire to not worry about the minutiae of everyday life. As a result, parents may wait until the last minute to complete records, and anecdotes from pediatricians describe some parents waiting until they are in the parking lot before they arrive for their scheduled appointment. This may not be an accurate reflection of the child's development over the course of several months.

To encourage parents and families to keep more accurate records in a way that can reduce some of these roadblocks or anxieties, we have designed and developed a computing system called Baby Steps. Baby Steps helps parents track both sentimental and developmental records and uses existing motivations to take pictures and share information with family and friends. It also aims to encourage parents to keep track of developmental records and provide supporting evidence using pictures and videos. Baby Steps uses the metaphors of a baby book and baby calendar with proactive reminders to help parents remember to regularly enter and

CHI 2009, April 4–9, 2009, Boston, Massachusetts, USA.

review data. Finally, it incorporates sharing features to encourage parents to communicate with friends, family, and pediatricians on their child's records.

We deployed Baby Steps with a set of 8 different families for a 3 month long small-scale study to determine its ability to help parents record their child's skills and communicate those decisions effectively to pediatricians. We proposed that four main design features would contribute to effective reporting and reflection: a proactive reminder system, the ability to create sentimental keepsakes, online data sharing capabilities, and an easy way to capture videos and pictures with a customized, integrated recording device. These features were tested in an experimental version of Baby Steps against a control version without these features. We hypothesized that these features would improve the parent's reporting experience along five dimensions, including the ability to capture more data, increased reflection upon data, increased confidence in parent reporting, improved timeliness in recording data, and improved communication between parents and their pediatricians. The results of the study show positive trends in each of these areas for the families in the study who used the proposed features.

The remainder of this paper is structured as follows. First, we begin with related work in using technology to support families, children, and record-keeping. Next, we describe the design and implementation of Baby Steps and present the study design we used to evaluate the system. We then present the results of the deployment study and provide a discussion for how this work can be used by designers to develop future applications in this domain. Finally, we conclude and provide future directions for this research.

RELATED WORK

This work builds upon previous research across three main research areas: supporting the needs of families, technology for the early detection of childhood disorders, and supporting data collection and analysis for health purposes.

Supporting Family Needs

Researchers have recently become interested in developing computing technology for families. Foucault conducted a cultural probe with new parents to determine their technological needs [11], which broadly examined all ways of supporting new parents. Our work is particularly focused on tracking developmental progress. Hutchinson *et al.* used technology probes to design technology alongside families by deploying systems with regular interactions [15]. Our work was inspired by this technique and uses a deployment of technology to evaluate and modify our initial design concepts. Dalsgaard *et al.* examined using technology to improve the relationship between older children and their parents, but their focus was on improving relationships and not on record-keeping [9]. Other work has explored how families use and share technology [5], how awareness technologies can support family communication [17], and how families coordinate busy schedules [20]. This work focuses on families with older children, whereas our work is focused on younger children.

Preserving family memories through annotating and organizing home movies with the Family Video Archive [1] and through storing memorabilia in various "memory boxes" [12, 23] has been another research focus. These technologies primarily aim for enjoyment, but they influence our work as solutions for storing health-based data in a way that is enjoyable and less "clinical." More closely related are several commercial software systems that have been designed to help preserve childhood memories, such as Tumblon.com [8] and Baby Album [24]. Though they address similar goals of preserving childhood memories, they do not have the specific goals of improving and motivating parent reporting. In addition, there are no studies evaluating their effectiveness. Other baby-focused websites, such as BabyCenter.com, offer to send regular updates about child milestones, but these reminders are often general and non-specific to a particular child [16].

Technology for Early Detection in Children

Previous research in the area of using technology for early detection of childhood disorders has been limited to a focus on automating the process of identifying early warning signs. The Human Speechome project [20] uses an extensive recording infrastructure throughout a house to gather linguistic data to help researchers ascertain how children acquire language. Fell *et al.* examined ways to analyze baby babble as early indicator of speech related disorders [10], and Westeyn *et al.* augmented toys with sensors to automatically identify developmental milestones in young children [25]. Our work seeks to support early detection using a more holistic approach, by using many different indicators for development, rather than focusing on a single domain or constrained set of clinical signs.

Collection and Analysis of Health Data

A tradition in health care is to collect data for maintaining a healthy lifestyle, making a diagnosis, or tracking a condition's progress. Researchers have become interested in designing computing technology to aid in the process of collecting and reviewing data. A full review of this area is beyond the scope of this paper, but there are several key similarities to this work in domains outside of caring for young children. Previous work has identified needs for technology for collecting and sharing data for seniors [7] and individuals with chronic conditions such as diabetes [18] and cancer [13]. Morris *et al.* identified a method for ubiquitously assessing health by embedding assessment techniques into existing practices [19]. There are similarities between domains in collecting and analyzing data. We are inspired by these successes and have applied similar techniques to a new domain with new challenges.

THE BABY STEPS SYSTEM

Baby Steps is software designed to encourage more frequent collection and review of a child's developmental progress. The system design was based on our formative study and design guidelines proposed in Kientz *et al.* [16] for designing technology for record-keeping for young children. We had five explicit goals for Baby Steps:

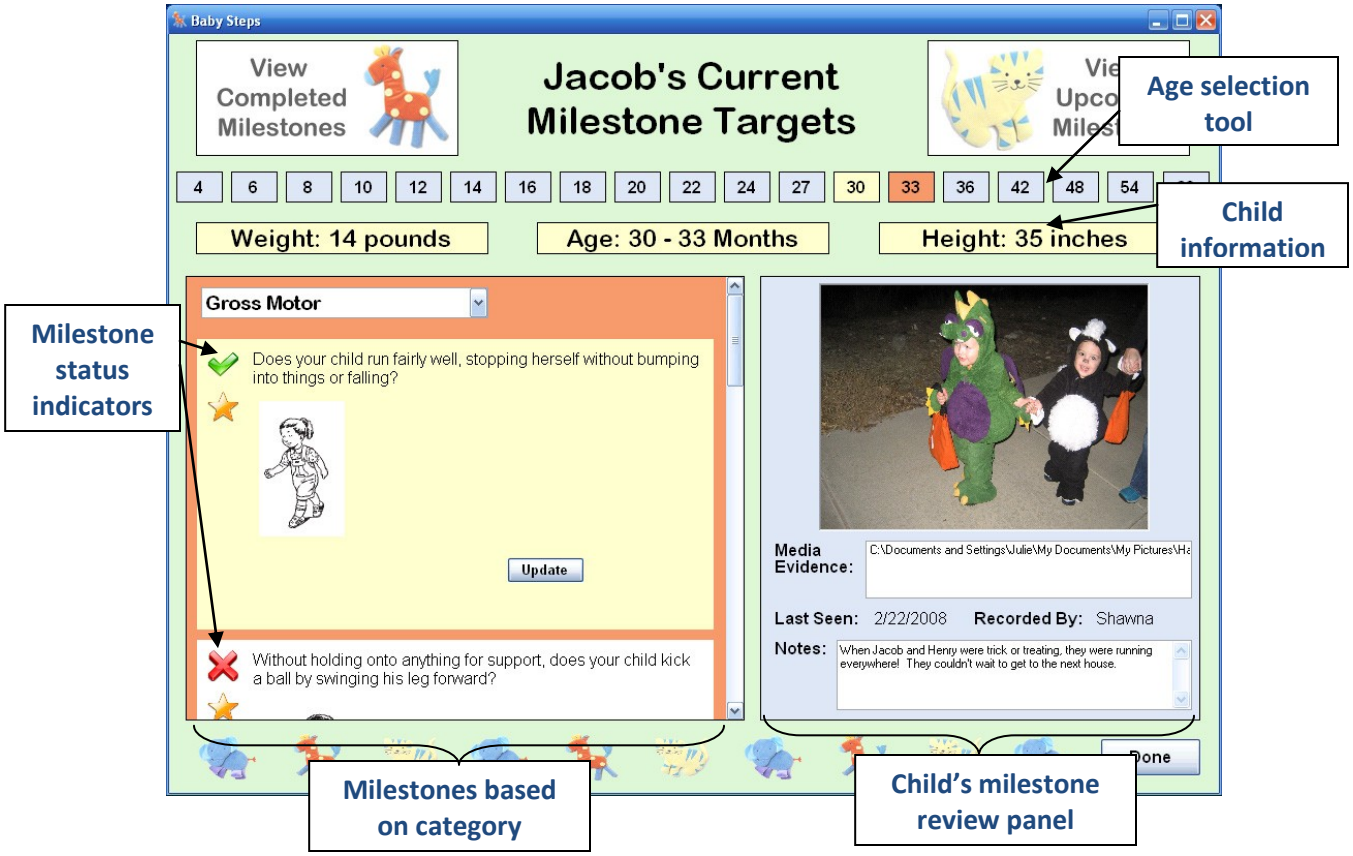

Figure 1: Main screen for viewing a child's milestone progress. Numbered links across the top are used to access different age ranges. The panel on the left contains milestone questions and icons representing the milestone's status. As the parent enters information, it is displayed on the panel to the right.

- Encourage recording of more data
- Encourage more frequent review of data
- Increase confidence in parent reporting
- Improve timeliness of parent reporting
- Improve communication between parents and health care professionals

These goals aimed to support the decision-making process that parents go through with regard to their child's developmental progress. In particular, these goals reflect those of Brassard and Ritter's guidelines for qualities of effective decision-making [3], which include providing more data, sharing with all involved parties, making timely decisions, and improving confidence.

Baby Steps Features

Baby Steps is a stand-alone software application that acts as a repository for storing information about a child or children using the metaphor of a baby book.

Main Features

Using the software application, parents have the ability to enter their child's developmental milestones according to the child's age. The milestones for our prototype system were based on the Ages and Stages Questionnaire [4], a developmental screening survey for children from birth to 5 years used in many pediatric offices across the United States. Each age range covers 2-3 months and consists of approximately 30 milestones across 6 categories (Communication, Fine Motor, Gross Motor, Problem Solving, Personal-Social, and Overall). Each milestone is phrased as a question, and parents must choose a response of "Yes," "Sometimes," or "Not Yet." Baby Steps also prompted parents to enter the date the milestone was observed, indicate which parent or caregiver observed it, upload pictures or videos of their child accomplishing that goal, and write general notes. The data can then be browsed easily, and parents can quickly scan to see which milestones they need to record. Status indicators show a green checkmark if the parent chooses "Yes," a yellow circle for "Sometimes," and a red X for "Not Yet." A star icon is also shown if the parents have associated a picture of video with the milestone. Figure 1 shows the main interface for entering and reviewing milestone progress. Milestone lists can also be easily printed so parents can bring them to the pediatrician's office. In addition to entering milestone information, parents also have the ability to write journal entries on their child's progress (similar to a blog), which are freeform in nature and can also have pictures and videos associated with them.

We designed the general GUI theme for Baby Steps using pastel colors and nursery-themed graphics and icons. The design was intended to be gender-neutral and appeal to both

parents and children. This theme was modeled after many baby book designs, which use many colors and decorative pictures for aesthetic and sentimental reasons and had the intention of appearing less like a medical record and more like a keepsake or scrapbook.

Experimental Features

We hypothesized that four key features would encourage parents to enter milestone information and associate photo and videos to each milestone, based on our formative study findings. First, parents can share associated videos with friends and family either via email or by uploading them to the video sharing website, YouTube.com. Second, parents desire a way to create keepsakes for their child, thus Baby Steps can automatically generate a PDF newsletter of their child's progress, which can be shared via email or printed for a scrapbook (see Figure 2). Third, parents need a way to remember to enter information if they are busy. Baby Steps provides daily popup reminders and email reminders sent every 3 days. These reminders contain three random milestones that the child has not yet completed (see Figure 3). Finally, parents require a way to easily capture and import videos and photos. Thus, we also developed a specialized recording device that takes pictures and videos and can easily be synchronized with Baby Steps. It uses video buffering to allow parents to record unexpected events [14] and also functions as a video baby monitor to encourage frequent use.

Figure 2: PDF newsletter automatically generated based on milestone information provided by parents.

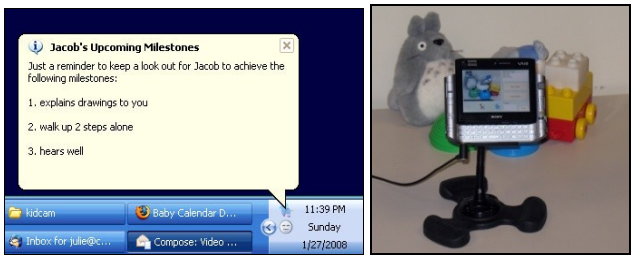

Figure 3: Daily popup reminder for upcoming milestones for a child (left) and customized recording device (right).

Implementation Details

We developed both the Baby Steps and the custom recording device using C# and a MS SQL database server installed locally on the machine. Video playback for Baby Steps uses the Microsoft Direct X libraries, and we implemented a custom DirectShow playback feature to provide the buffering capabilities and playback of video on the custom recording device. Baby Steps runs on a Microsoft Windows XP machine and uses a Windows service for the reminder system. We prototyped the custom recording device on a Sony Vaio-UX ultra mobile PC (UMPC) for ease of development, custom interface design, storage space, and sufficient processing for the video buffering. The UMPC also had a built-in touch-screen, camera, microphone, wireless connectivity, and was portable enough to be taken anywhere. We used a Nokia N800 as the remote viewing component for the baby monitor, which mirrored the screen of the UMPC over a wireless connection.

STUDY DESIGN

To determine if Baby Steps met our five explicit goals for improved record-keeping, we conducted a small-scale deployment study for a 3-month period with 8 families. In this study, families used Baby Steps to record and review real data on their child's developmental progress. We devised a study that allowed us to test whether the four experimental features described above would encourage parents to record more data and make better decisions about their child's progress. To test these features, we deployed two versions of Baby Steps: an experimental version with the four hypothesized features included and a control version that included everything except those four features. For the control version, all families had access to a digital camera with video recording capabilities instead of the custom recording device. We implemented a between-subjects study design to test of the experimental versus control systems, where 4 families received the experimental version of Baby Steps and 4 families received the control version. We also conducted several within-subjects tests for each family by administering surveys, interviews, and observations of Well Child Visits at both the beginning and end of the study to see whether there were any changes before and after the deployment of either version.

Participant Selection

We recruited a pediatricians' office in suburban Atlanta, Georgia consisting of two doctors who already used the Ages and Stages Questionnaire with their clients and had never met the researchers or seen Baby Steps prior to this study. To recruit the 8 families, we mailed 90 study description letters and screener surveys to the office's patients with a child nearing 9, 12, or 15 months that would be scheduling checkups for those ages soon. The screener survey asked basic information about the composition of the family, demographic information, computing equipment at home, and experience with computers. We received 28 screener surveys from which we selected 4 pairs of families that matched on various family and demographic criteria

(see Table 1). We randomly assigned one of each pair to the control group and one to the experimental group. These matching pairs ensured that we would have a counterbalanced experimental design. Families were not told whether they were in a control group or an experimental group, and neither families nor the pediatricians knew that there were two different versions of the systems deployed for the study. All families consisted of parents of a similar demographics and socio-economic status to control for as many external factors as possible. Thus, all parents were married, middle or upper-middle class, were in their 30s to 40s, and were college educated or currently attending college. All parents were American except for C-2 (both parents born in South Korea) and E-2 (father born in South America).

Table 1: Participant families and demographics selected for the two groups.

ID	Group	Doctor	Child's Initial Age	Gender	# Siblings	Both Parents Working?
E-1	Experiment	P-1	12 months	M	1	No
C-1	Control	P-1	12 months	M	1	No
E-2	Experiment	P-2	9 months	M	0	Yes
C-2	Control	P-2	9 months	F	0	Yes
E-3	Experiment	P-1	9 months	M	1	No
C-3	Control	P-1	9 months	M	1	No
E-4	Experiment	P-2	15 months	M	1	Yes
C-4	Control	P-2	15 months	M	1	Yes

Data Collected

We collected a significant amount of data to evaluate Baby Steps' success in achieving its five goals stated above. To determine whether parents recorded more data, we logged all information entered by the parents. We recorded the number of times the system was used and which features were used frequently to determine how often parents reviewed data. To measure confidence levels of parent reporting, we had parents rate their confidence on a scale of 1 to 5 (5 being highest) for a list of age appropriate developmental milestones before and after using Baby Steps. We measured the effectiveness of communication between the parents and pediatrician using a standardized survey instrument [2] completed by both parents and pediatricians. Finally, we measured the timeliness of the recording or reviewing of the data by logging the dates at which data was recorded. We also conducted interviews with families and focus groups with pediatricians before, during, and after the study as a means of triangulation.

Study Timeline

We met with each family five times over the course of the 3 months. The first meeting was an observation of the Well Child Visit between the pediatrician, parent, and child where we also distributed pre-study surveys. Shortly after the Well Child Visit was a home visit to install Baby Steps on the family's computer and conduct an initial interview. The parents then used Baby Steps uninterrupted for approximately 1-2 months. Halfway through the study, we visited the families again to download software logs and conduct a mid-study interview. After approximately 3 months, we observed the child's next Well Child Visit and distributed the same surveys as during the first visit. Shortly after the second Well Child Visit, we made a final home visit during which we downloaded log files and conducted a final interview on families' experiences using Baby Steps and suggestions for improvements and new features.

RESULTS AND DISCUSSION

This section presents findings from data collected during the deployment study of Baby Steps. We present results showing the effects on the amount of data collected and reviewed, confidence in reporting, timeliness of reporting, and improvements to communication between parents and pediatricians. We also discuss the overall reaction the system and suggestions parents had for improvement.

Increasing Data Capture

Baby Steps aimed to help parents and pediatricians determine progress based on data and evidence, rather than opinion or instinct alone. Thus, we wanted to assess whether the four experimental features encouraged the capture of more data. We analyzed the logs and database files for each family to determine how many milestones were recorded and how many photos and videos were associated as evidence for those milestones (see Table 2). On average, we found that the experimental group recorded a higher number of milestones when compared to the control condition (90.5 vs. 48.5; $p=0.16$[1]; Cohen's d effect size = 1.19) and a higher number of pictures and videos (10.5 vs. 2.75; $p=0.20$; Cohen's d effect size = 1.004).

Parents who did not enter much data reported several reasons. One of the control group participants mentioned that she needed more motivation to take the time to use the software, and that one possible way of motivating her would be the ability to share her child's data online.

Mother, C-1: "*I need to be motivated. I think if there was some way of sharing the information online or posting it to a website, then I would be more motivated to put data in it. Right now I just enter it, and it doesn't go anywhere.*"

In the experimental group, one of the parents mentioned that while she recorded all the milestones on her child's development, she only felt compelled to record pictures or videos if she was not sure of her answer.

Mother, E-1: *"If I knew it, then I wasn't going to record it. But if I wasn't sure, then I got the video thing out and I went through the*

[1] We used Independent Sample T-Tests with equal variance assumed to test significance. For p values greater than 0.05, we also calculated Cohen's d, which measures the effect size. A Cohen's d greater than 0.8 indicates a large effect size [6].

list of what I wasn't sure of. Like I really wasn't sure about, for example, that throwing the ball. And even when I got it on video I replayed it a couple of times to make sure… like did he really throw that, or was it a drop?"

Table 2: Number of milestones, pictures, and videos recorded and the number of days families used Baby Steps.

Participant ID	Milestones Recorded	Pictures & Videos	Days Accessed
C-1	64	8	6
C-2	12	0	10
C-3	5	0	3
C-4	113	3	7
E-1	74	22	16
E-2	79	4	22
E-3	101	0	23
E-4	108	16	20
Control Average	45.8 (σ = 50.41)	2.75 (σ = 3.77)	6.5 (σ= 2.89)
Experimental Average	90.5 (σ = 16.54)	10.5 (σ = 10.24)	20.25 (σ= 3.09)

Increasing Data Access

We also wanted to know if Baby Steps encouraged parents to reflect upon data more often. We examined the use of the system via log files to determine how often parents viewed their child's milestones over the course of the 3 months. On average, parents in the experimental group accessed their child's data across more days than the control group (20.25 days vs. 6.5 days; $p < 0.01$). Table 2 shows the number of individual days of access by each family in the study, and Figure 4 shows a distribution of these accesses over the 3 months of the study, showing for the most part, that access was distributed across the days of the study. In post-study interviews, parents in the control group reported forgetting to use the system or stated there was not enough time. All parents in the experimental group reported that the reminders helped to think about using the system.

Mother, C-3: *"Because when you do have down time, if you could remember instead of picking up a book and reading it. You know, you just don't think about it."*

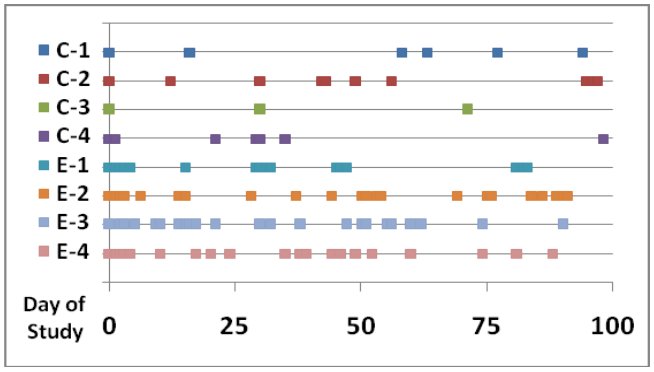

Figure 4: Plot of days Baby Steps was accessed across the 3 months of use.

Increasing Confidence in Reporting

Another aspect of record-keeping we aimed to support was increasing confidence in reporting developmental progress. To measure confidence, parents completed the paper-based version of the Ages and Stages Questionnaire for their child at both the beginning and end of the three months (each questionnaire consisted of approximately 35 questions). For each milestone, we also asked parents to rate the confidence of their "Yes," "Sometimes," or "Not Yet" response on a scale from 1 to 5 (where 5 is highest confidence).

To analyze the survey results, we averaged the total number of responses for both within-subjects and between-subjects conditions. For the within-subjects comparison, there was an increase in confidence for all 8 participants between the first stage of the study and the second stage of the study, 5 of which were statistically significant ($p < .05$) (see Figure 5). For the between-subjects comparison, we compared the average differences between the beginning of the study and the end of the study. For the control group, the average difference was 0.52 (σ = 0.53). For the experimental group, the average difference was 0.56 (σ = 0.39). The average difference between the two groups was fairly small ($p = 0.96$). The overall findings suggest that although there was a difference for almost all of the participants in terms of the within-subjects gains, there was not a statistical difference between the experimental and control groups.

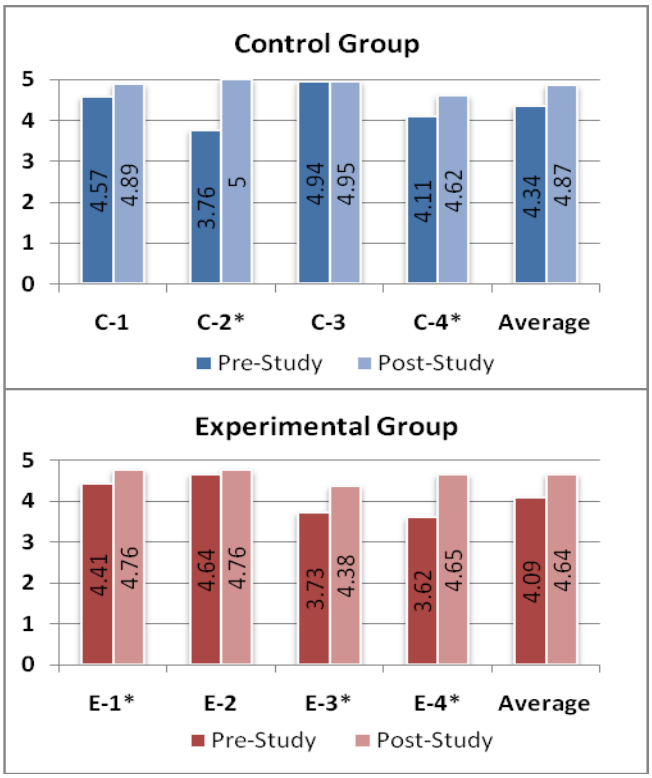

Figure 5: Average confidence ratings for each family. An asterisk denotes statistically significant differences.

In the post-deployment interviews, participants from both groups reported that using the Baby Steps software in general helped increase their confidence and awareness of

their child's developmental progress. In particular, one parent mentioned that although she had a general sense of how her child was developing, using Baby Steps helped her to be more aware of some of the more minor milestones.

Mother, E-3: *"[I'm] more aware of much more specific things. Like there's the big obvious ones like talking and walking and stuff, but yes, it was very interesting to know all the different categories and everything under the different categories."*

Improving Timeliness of Reporting

Ideally, parents would report their child's developmental progress more frequently and more evenly spaced over the time between pediatrician visits, rather than all clustered on a single date. To get a sense of whether Baby Steps encouraged this practice, we logged the dates that parents entered milestone information into the system. With these dates, we could determine how often parents entered data and how long they took between reporting. In general, we found that the experimental group entered data on more unique days on average than the control group (12.25 days vs. 6.75 days); ($p = 0.22$). Parents in the experimental group also averaged a shorter amount of time between days that the decisions were made (10.62 days vs. 17.54 days); ($p = 0.34$). Finally, we looked at the longest gap between entries (*i.e.*, the highest number of days between two reports) and found that the experimental group's average longest gap between entries was shorter than that of the control condition (26.75 days vs. 42.67 days out of a possible 90); ($p = 0.21$). The trends for these groups show promise for improving timeliness and in the post-study interviews, some participants acknowledged this trend.

Mother, E-1: *"When Dr. [P-1] first gave me the 12-month questionnaire it was at the 9-month appointment... And like that was just stuck in this folder. But then when I started working with [the system], then it was something I was constantly interacting with and using. Even if it wasn't a daily thing. It was something that I was being able to be more aware of instead of pulling it out the day before his check-up and going over the list."*

Improving Communication

One final goal for Baby Steps was improving communication between parents and their pediatricians. We analyzed the perceived collaboration levels from the parents' perspective using a modified version of a standardized survey called the Patient-Doctor Interaction Scale, or PDIS [2]. The modified PDIS consisted of 21 statements probing a variety of satisfaction levels, such as communication, rapport established, and satisfaction with care received. The ratings used a 5-point Likert scale, with 5 always being the positive answer. We created a similar 18-question survey for pediatricians to rate parents, with a focus on the parents' knowledge about their child's development and the productiveness of their appointment. We administered these surveys immediately following the Well Child Visits at the beginning and end of the study.

Analysis of the parent-completed surveys showed that in general, there was a net decrease in the average ratings for the control group (-0.11, $\sigma = 0.31$) and a net increase in the ratings for the experimental group (+ 0.14, $\sigma = 0.36$) between the two phases of the study. The difference between the averages for the two groups was significant ($p < 0.05$). An analysis of the pediatrician-completed surveys showed an increase for both groups between the two phases of the study. However, there was a bigger increase for the experimental group (+ 0.51, $\sigma = 0.34$) than for the control group (+ 0.18, $\sigma = 0.31$); ($p = 0.01$). Figure 6 shows two charts showing the differences between the pre-and post-study surveys of both types for both groups.

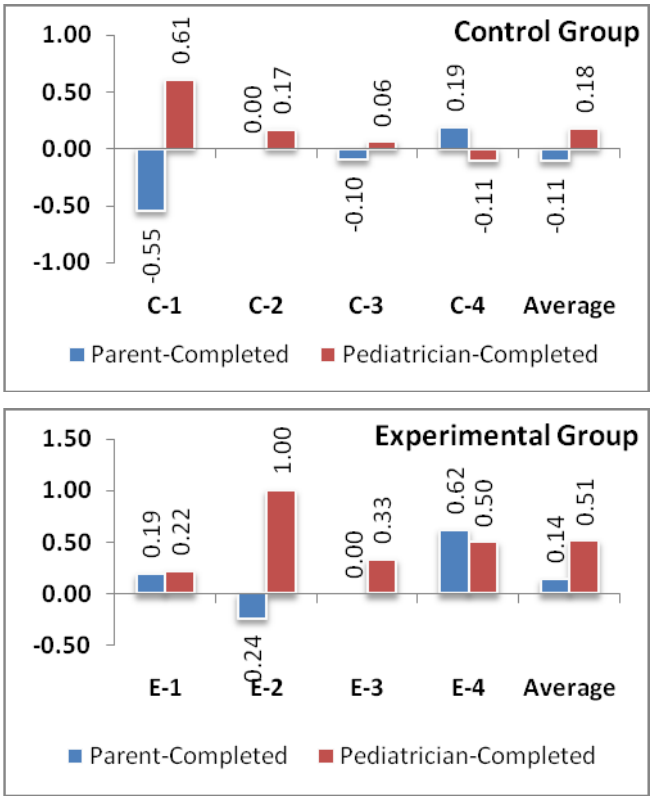

Figure 6: Charts showing the differences in perception of communication between parents and pediatricians between the beginning and end of the study.

Another interesting result of this survey is that perceptions of communication were not necessarily reciprocal. For example, for C-1, the difference between the pre-study and post-study ratings by the parent showed the biggest decrease between the two phases (-0.55), whereas the rating by the pediatrician for this parent showed the biggest increase (+0.61). A similar trend is shown for participant E-2, where the difference from the parent's perspective showed a decrease of 0.24, whereas from the pediatrician's perspective, it showed an increase of 1.00. The mother of family E-2 indicated in the post-study interview that she felt more organized for her doctor's visits.

Mother, E-2: *"I just have lots of questions for [Dr. P-2]... before, I would write them down and keep them in, like, my nightstand drawer, but now that I have [Baby Steps] it's easier for me because I'm always on the computer. I feel so organized when I go and I can just print out the list."*

One possible explanation for this observation may be that as parents become more aware of their child's developmental progress, from the pediatrician's perspective this is seen as a positive change because they are more aware. However, parents who are more knowledgeable may begin to question the pediatrician's depth of evaluation. We believe that this result indicates that more research into a deeper understanding the nature of the parent/pediatrician relationship is needed.

One final result of interest in the area of communication is that for six out of the eight families in the study, one parent primarily took on the role of entering data or deciding on the child's developmental progress. For those families, that parent was the mother, and she was the only one who attended the Well Child Visits. The exceptions to this were family C-1, where both parents attended both visits in the study, and E-4, where the mother attended the first visit and the father attended the second visit. In both of these families, both parents used the system collaboratively. However, in other families, the other parent might help take pictures and videos and otherwise be involved with the child, but they rarely participated in the after-the-fact recording and reviewing of data. This observation indicates that designers should take into consideration ways that the secondary caregiver could be encouraged to be more active in the data recording process.

Overall Impressions and Suggestions for Improvement

During the post-deployment interview, we asked parents about their general perceptions and suggestions for improvement or new features. Most families had a positive reaction to the Baby Steps system. The exceptions to this were families C-2 and C-3, who very rarely used it to record their child's milestones. The mother of C-2 cited that she just never remembered to use it. The mother of C-3 had an existing solution of recording her daughter's important moments (*e.g.*, words she knows, teeth that have grown in, *etc.*) in a text file she stored on her computer. She said that it was faster and easier to do that, and since her daughter was always above average, she had no reason to want to keep milestone records. The mother of family E-1 was the most enthusiastic about the system. Her older son had shown warning signs of autism at a young age, and so she was worried that her second son (the one participating in our study) was also at risk and wanted to watch him closely.

Mother, E-1: *"With my first child, I felt kind of like, almost like nervous between one well visit and the next because I was really on my own. And so this made me feel more comfortable about [child's name] because I knew what to look for."*

Interestingly, parents from the control group requested features that existed in the experimental version, such as reminders and the ability to share their child's data with others. Parents who used the hypothesized features appreciated their existence, but had suggestions for improvement. Most parents wanted to be able to customize the frequency of the reminders that were sent, as they felt the default was too frequent.

Mother, E-1: *"I liked some reminders, but not necessarily as many reminders. Because if you get too many, then you start ignoring them."*

Parents in the experimental group rarely used the video and picture sharing feature, mostly because they already used other tools to accomplish that task. However, they appreciated the ability to generate a newsletter of their child's progress.

Mother, E-3: *"So I like the newsletters, like, to be able to send to grandparents or stuff. You know, I'm not going to send them a whole baby book."*

The video recording device we prototyped was not frequently used by those families in the experimental group. The functionality to use it as a baby monitor was more complicated than typical monitors, so most families did not use it continuously. However, several families would set up play sessions with their child and used the video buffering capabilities for recording unplanned, interesting moments.

Father, E-4: *"Before, he'd do something and it would be so fascinating, and then when you try to get the video to record it, the process of going to get it, or whatever, set it up. Then he'll be distracted by it, and it's like, 'Oh, let me look at the toy.' Rather than do the trick. Now, we can get it if it's on."*

Many parents from both groups had suggestions for how Baby Steps could be improved. Almost every parent wanted explicit suggestions for more sentimental records that they could enter into the system, such as first vacations, first haircuts, favorite toys, or family trees. Though they could enter this information using the journal feature, they wanted to be prompted by specific questions. Also, we designed Baby Steps as a stand-alone application for health data privacy reasons, but many parents requested a web-based or network-enabled version, so they could access it from any computer.

Mother, C-4: *"Maybe you could even have this be online? I was thinking that I would use it more, because I was on my Mac a lot. I would have just gone to the website from there."*

Parents were also naturally curious and wanted to know how their child compared to the average child. Several suggested including average development rates or charts so they could visualize their child's progress over time. We did not include this information for fear of invoking anxiety if progress was slower than average, but when probed about this possibility, most said they would want to know so they could act upon the findings.

Mother, C-4: *"Even if it's just a little note after the thing saying, 'On average 50% of kids [do this].' I know that's a lot of information, but I want to know."*

Mother, E-1: *"I'd rather know. I get anxious not knowing. And then I know what to work on, you know? Because you can work on it with play. It's not like it's a chore."*

Several parents wanted to be able to keep a history for each milestone. With Baby Steps, they could only update existing data and one parent mentioned being hesitant to

update a note she had made about a milestone, because she wanted to be able to store that for later reference. Finally, many parents requested a search function, as the current system only allowed for browsing by age and category.

Mother, E-2: *"I had a video of [child's name] stacking rings. I knew that must be a milestone, but I didn't want to browse through everything to find it."*

DESIGN CONSIDERATIONS

The deployment of Baby Steps uncovered some insights into how computing applications for this domain can succeed or fail. These findings can serve as guidelines for the design of future applications. In this section, we discuss various lessons learned and aspects of the design we believe had an impact on the results presented above.

Provide explicit guidance for busy parents to enter information. Although some parents enjoy coming up with their own information to enter about their child, many do not think to write specific data without some sort of guidance. Many parents requested ideas for data and topics to record about their child and appreciated the fact that milestones were pre-entered and thus they could just mark "yes" or "no" rather than having to write long descriptions. Thus, we believe Baby Steps could be even closer to existing baby books by asking more sentimental questions. However, we believe still providing the opportunity for some free-form entry will make the system flexible enough that parents can use it for a variety of tasks.

Quality of artifacts used for sentimental purposes is important. Because Baby Steps was a research prototype created with limited resources, the design and implementation of the system was not as high of quality as one would expect from a commercial system. For example, the pictures captured by the Sony Vaio UMPC were lower quality than digital cameras. The method used to make the recording device into a functional baby monitor was also cumbersome to use and thus parents quickly dismissed it. Lastly, the newsletter generated by the system was listed as questions rather than statements, so parents were less likely to want to share it for fear of confusing others. Thus, the importance of visually appealing long-lasting artifacts should not be underestimated.

Perception of communication is not necessarily reciprocal. As seen in the results of the analysis of ratings of communication amongst the parents and the pediatricians, there can be a difference between how collaboration is perceived amongst different members of the care team. Thus, it may be considered that having more information may actually make caregivers perceive others as not doing as much as they could. Technologies to support caregivers should take the differing roles into consideration and make advancements to help all members of the care team to understand each other's roles and be on the same page about how care is progressing.

Provide examples to elicit interest in completing a task. Having specific examples would be helpful in sparking interest or ideas for what a parent might enter in free-form entry boxes. Many parents did not use the "Note" field for entering milestone information, because they were not sure what would be appropriate to write in that space. Similarly, parents did not necessarily know what the newsletter was capable of until they had data entered into the system, so it is possible new users may not fully appreciate the extent to which a system could be used without having a previous example. Thus, having examples for what a parent might want to record would be helpful in getting them to enter more data or use additional features.

Adaptation of system for those with limited financial means. The participants in our study were all in a position to afford home computers with internet access, but this technology should also aim to benefit those with limited financial means. The pediatricians reported a concern about this, as many low income families are often the ones that are under diagnosed. If Baby Steps were web-based, it would alleviate the need for owning a computer, as public libraries and workplaces often offer free Internet access. However, the system still relies on digital pictures and videos, which usually require at least a digital camera if not a camcorder. Potential solutions may be to use mobile phones, which may be more economically feasible than a computer with an internet connection, or provide kiosks at public health clinics. These areas remain open for future exploration.

Designing for limited anxiety. One danger in designing systems to support better tracking of medical or developmental data is that it may cause unnecessary worry over progress. We tried to avoid this danger by presenting Baby Steps as not only a developmental tracking tool, but also a sentimental record-keeping tool. We also made a conscious decision to not provide any analysis of the questionnaire by the system, but to only allow parents to print the list of milestones for their pediatrician to analyze. None of the parents in the study reported an increase in their anxiety levels when asked, but could imagine being concerned if their child was not progressing normally. We believe further research may be necessary to determine better ways to present potentially sensitive information.

CONCLUSIONS AND FUTURE WORK

Helping new parents keep better records about their children has the potential to achieve numerous personal and public health goals. In particular, by more closely and continuously tracking a child's progress, parents may identify the warning signs of a potential developmental problem earlier than they might have otherwise. Existing record-keeping techniques lack the ability to provide a consistent and integrated location for recording all information about a child's development, including developmental, medical, and sentimental records.

In this paper, we presented the design, implementation, and evaluation of a computing system aimed to meet these needs. The system, called Baby Steps, used four specific design features to encourage parents to record and review

information more frequently, including the ability to share information with others, the ability to generate keepsakes, proactive reminders, and integrated video and photo recording tools. A 3-month small-scale deployment study test the ability of these features to support parents in keeping better records. Results showed promising trends through more frequent recording and review of data, improved perceptions of collaboration, increased parent confidence in reporting, and timelier record-keeping.

Although this study showed significant findings in how technology can support record-keeping, there are still many areas for future exploration. We plan to conduct future studies to identify more specifically how our four experimental features individually contributed to the improved record-keeping. We also plan to conduct a larger study with a more diverse set of users for a longer period of time. We plan to adapt this technology to support those with varying financial means and reduce the necessity of owning expensive technologies while still providing the same benefits. In addition, this domain can be used as a means for studying appropriate ways to design technology in such a way that it can limit the anxiety involved in collecting potentially negative data. The implications of these findings can reach beyond the domain of young children to those needing to care for another individual.

ACKNOWLEDGEMENTS

We thank the families and pediatricians who participated in our study. We also thank Arwa Tyebkhan, Krystian Alberciak, Stefan Puchner, Yi Han, Tracy Westeyn, Khai Truong, Shwetak Patel, Gillian Hayes, and Arya Irani for their assistance in this effort. This work was supported by the National Science Foundation under Grant No. 0745579.

REFERENCES

1. Abowd, G.D. The Family Video Archive: An annotation and browsing environment for home movies. In Proc. of MIR '03. 2003.
2. Bowman, M. A., Herndon, A., Sharp, P. C., & Dignan, M. B. Assessment of the patient-doctor interaction scale for measuring patient satisfaction. Patient Educ. Couns. pp. 75-80. 1992.
3. Brassard, M., & Ritter, D. Memory Jogger II. Methuen, Mass: GOAL/QPC. 1996.
4. Bricker, D.D., Squires, J., Potter, L.W., & Twombly, R.E. Ages & Stages Questionnaires (ASQ): A Parent-Completed, Child-Monitoring System. Paul H. Brookes Publishing CO. 1999.
5. Brush, A.B., & Inkpen, K. Yours, Mine and Ours? Sharing and Use of Technology in Domestic Environments. In Proc. of Ubicomp '07. 2007.
6. Cohen, J. (1988). Statistical power analysis for the behavioral sciences (2nd ed.). Hillsdale, NJ: Lawrence Earlbaum Associates.
7. Consolvo, S., Roessler, P., & Shelton, B. The CareNet Display: Lessons Learned from an In Home Evaluation of an Ambient Display. In Proc. of Ubicomp '04. 2004.
8. Dahl, J., Scharf, G., & Francl, L. Tumblon. Retrieved September 2008, from Tumblon: http://tumblon.com
9. Dalsgaard, T. *et al*. Mediated intimacy in families: understanding the relation between children and parents. In Proc. of Interaction Design and Children. 2006.
10. Fell, H., Cress, C., MacAuslan, J., & Ferrier, L. visiBabble for reinforcement of early vocalization. In Proc. of Accessibility and Computing. 2004.
11. Foucault, B.E. Designing Technology for Growing Families. Technology@Intel Magazine. 2005.
12. Frohlich, D., & Murphy, R. The Memory Box. Personal and Ubiquitous Computing. 2000.
13. Hayes, G.R. et al. Opportunities for Pervasive Computing in Chronic Cancer Care. In Proc. of Pervasive 2008. pp. 262-279.
14. Hayes, G.R. *et al*. Experience buffers: a socially appropriate, selective archiving tool for evidence-based care. In Ext. Abst. of CHI '05. 2005.
15. Hutchinson, H., *et al*. Technology probes: inspiring design for and with families. In Proc. of CHI '03. pp. 17-24. 2003.
16. Kientz, J.A., *et al*. Grow and Know: Understanding Record-Keeping Needs for the Development of Young Children. In Proc. of CHI '07. 2007.
17. Khan, V. and Markopoulos, P. 2009. Busy families' awareness needs. Int. J. Hum.-Comput. Stud. 67, 2 (Feb. 2009), 139-153.
18. Mamykina, L., & Mynatt, E.D. Role of Community Support in Coping with Chronic Diseases: A Case Study of Diabetes Support Group. HCI International. 2005.
19. Morris, M., Intille, S.S., & Beaudin, J.S. Embedded Assessment: Overcoming Barriers to Early Detection with Pervasive Computing. In Proc. of Pervasive 2005.
20. Neustaedter, C., & Brush, A.J. "LINC-ing" the family: the participatory design of an inkable family calendar. In Proc. of CHI '06. pp. 141-150. 2006.
21. Roy, D. *et al*. The Human Speechome Project. Cognitive Science, pp. 192-196. 2006.
22. Shore, R. Rethinking the Brain: New Insights Into Early Development. Families and Work Institute. 1997.
23. Stevens, M.M. *et al.* Getting into the Living Memory Box: Family archives & holistic design. Personal and Ubiquitous Computing, 2003.
24. Virtualsoft, Inc. Baby Album. 2008.
25. Westeyn, T.L. *et al*, Designing Toys with Automatic Play Characterization for Supporting the Assessment of a Child's Development. Workshop at IDC '08.