Understanding Parenting Stress through Co-designed Self-Trackers

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ABSTRACT
New parents often experience significant stress as they take on new roles and responsibilities. Stress management and mental wellbeing are two areas in which personal informatics (PI) research has gained attention, and there is an opportunity to investigate how parenting stress can be mitigated through PI practices. In this paper, we present the results of a co-designed technology probe study through which we deployed individualized self-trackers with new parents. We investigate the stress management topics new parents are interested in tracking and how—and with what goals—they engage in self-directed PI practices. Our findings indicate that PI practices can potentially enable parents to: re-discover positive aspects of their everyday lives; identify better-suited stress management strategies; and facilitate spousal communication about shared responsibilities. We discuss how self-tracking experiences for the mental wellness of parents can be better designed.

Author Keywords
New parents; parenting; stress management; self-tracking; personal informatics; co-design

CCS Concepts
•**Human-centered computing** → **Empirical studies in HCI;**

INTRODUCTION
New parents face various challenges as they undergo radical physical, emotional, and social transitions. Taking on new roles and responsibilities, their routines are dramatically changed and their resources to socialize with others are significantly reduced, which contributes to feelings of stress, anxiety, depression, and loneliness. Moreover, individuals who are living far away from their family and friends, such as immigrant parents, are at greater risk of severe parenting stress because of lack of support resources and feelings of isolation [63, 12].

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Through the study presented in this paper, we build on prior work in the area of personal informatics (PI), which suggests the potential for PI to promote an individual's wellness by providing data-driven self-insight into various aspects of one's daily life. These kinds of self-insight through self-tracking include concerns with physical wellness, such as managing diabetes [61] and physical activity [19], as well as mental wellness, such as sleeping behavior [25] and emotions [26, 31, 32]. Several researchers have also proposed PI systems to support serious mental health problems such as bipolar disorder [14, 36]. For our purposes, we have explored the potential for PI practices in mitigating stress and stress response behaviors, which we will discuss more in a later section.

The unique circumstances that new parents face, which often lead to feelings of social isolation and distress, present opportunities and challenges in addressing parenting stress with PI practices. Not only can PI practices provide new parents with data-driven self-insights, which often lead to positive behavioral changes [19], but they can also play a therapeutic role through self-expression to regulate negative emotions [32, 60]. In this paper, we present the results of a co-designed technology probe study through which we deployed individualized self-trackers with new parents. We enrolled five new parents in a two-week deployment of co-designed self-trackers and investigated how new parents in our study adopted the flexible self-tracking tool we provided to them, as well as how they engaged in self-directed PI practices for managing stress in their daily lives. Even though our participants were all mothers who were playing the role of primary caregiver, we sought to provide implications that can be applied to both mothers and fathers. Our ultimate goal was to inform the design of PI systems that support new parents. In this paper, we use 'flexible tracking' to refer to the customizable self-tracking practices that satisfy individuals' various tracking needs, preferences, and goals [28].

The key contributions of this work are twofold:

- We discuss the opportunities and challenges of parenting stress management, drawing on the findings from two weeks of self-tracking experiences of five new parents with a specific focus on the social nature of a group workshop.
- We inform the design of self-tracking experiences for new parents in three directions: 1) leveraging flexible self-tracking practices to help individuals gain self-knowledge for better stress management; 2) re-discovering positive

moments of daily life through self-tracking practices; 3) supporting family-centered PI practices by promoting data-mediated communication among family members.

RELATED WORK

We organize the literature upon which this project is built into the following categories: parenting stress, personal informatics for stress management, and personal informatics for parenting. In this section, we outline the prior work in each of these areas, before integrating them through our study and discussion.

Parenting Stress

The transition to parenthood can be exciting but stressful for every parent because it often requires radical lifestyle changes [10]. One popular way to examine factors that influence parenting stress among academic articles is to use the Parenting Stress Index, which consists of the three sub-scales: parental distress, dysfunctional parent-child interaction, and difficult child [1]. While some studies reported that child behavioral problems or difficult temperaments have the closest relationship [44], others found that parents' psychological distress is the most strongly related area to parenting stress [64].

There is evidence that parents experience increased levels of stress due to loneliness and social isolation [24, 33]. Stay-at-home mothers taking on the primary caregiving roles are especially likely to be socially isolated compared to working mothers, and are also more likely to experience increased feelings of depression [9] and anger [13]. However, this is not to suggest that working mothers have it easier, as they are likely to experience increased stress dealing with multiple roles as well [45]. On top of the potential stressors in transition into parenthood presented above, recent immigrant parents are likely to be exposed to more stressors due to separation from family and friends, language barriers, cultural differences, and struggles with adjustment [63].

Indeed, social support is one of the most frequently mentioned factors that mediates or buffers parenting stressors (see, e.g., [30, 8, 54]). As feelings of isolation is one of the critical causes of parenting stress, appropriate social support can moderate parenting stress [12, 37] by supporting individuals to deal with role transition into parenthood [2]. Specifically, recent research has demonstrated that parents in transition often seek social support to overcome isolation by engaging in strategic self-disclosure in social media [3, 4, 11].

However, most of the studies on parenting stress focus on its impact on negative parenting behaviors such as child abuse instead of parental psychological well-being itself. Research has repeatedly determined that abusive mothers experience greater stress than non-abusive mothers and that more attention is needed in promoting the mental wellness of parents [62, 54].

Such complexity of parenting stress brings unique challenges in supporting stress management of parents with technology; not only is it difficult to determine what factors, if any, could be tracked to help parents better-manage their stress, it is also difficult to understand what factors would be *desirable* for parents to track. In our study, we introduced a flexible self-tracking tool as a probe, allowing parents to identify (and iterate) on what stress-related factors they would like to track, effectively co-designing their PI trackers. This information, we argue, can serve as a foundation for the design of self-tracking tools to support the mental wellness of parents.

Personal Informatics for Stress Management

A significant body of work within HCI informs the design of PI systems to better support the mental wellness of individuals. Most of this work predominantly relies on quantitative approaches utilizing biosensors to detect the root causes of stress [17, 47] and to visualize an individual's biosensor data for stress intervention [51, 65, 49].

However, there is an opportunity for research in this space to contribute to an in-depth understanding of the context and underlying issues of an individual's mental wellness [32], which may be best-engaged through qualitative approaches. Furthermore, previous research on PI practice to support mental wellness has predominantly focused on serious mental health problems such as bipolar disorder [14, 36]. However, researchers have argued that coping with daily stress deserves more research attention in the field of PI due to the unique challenges it brings into PI practices such as the difficulty in determining what to track to improve one's mental wellness and the potential impacts of closely monitoring negative emotions (e.g. further demotivating individuals with vulnerabilities and thus resulting in higher levels of depressed mood) [26, 59, 58]. Therefore, there is a need for an exhaustive investigation into how individuals make use of PI systems to better support how they deal with daily stress.

Personal Informatics for Parenting

There have been many attempts to support parenting with PI systems. Most work is related to how to support parents collecting data related to the general development or health of a baby [20, 27]. Wang et al. [57] and Lupton et al. [35] show that employing a PI system for tracking data related to children not only enhance parents' understanding of their patterns but also alleviate the burden of parenting by reducing the need of frequent physical checking of babies and offloading baby-related information to mobile applications. However, monitoring babies with ubiquitous technologies turned out to increase parents' anxiety in some cases [57], which shows the need for considering parents' emotional wellbeing when designing technologies to support parenting.

An opportunity space for related research that this highlights for us is in leveraging PI practices to engage more explicitly with parental mental wellness. Despite the potential benefits of PI practices based on prior works such as providing self-insights [19] or therapeutic effects [60], few studies consider the mental wellness of parents with PI systems. Therefore, in this study, we set out to explore how new parents adopting a flexible self-tracking tool and engaging in self-directed PI practices in the context of stress management could inform the future design of mental wellness PI tools.

METHOD

The goal of this study was to investigate how new parents make use of a flexible self-tracking tool and engage in self-directed PI practices in the context of stress management with

the ultimate goal of informing the future design of mental wellness PI tools. To that end, we recruited five new parents to engage them in the co-designed technology probe study.

Research Approach

To investigate how new parents adopt a flexible self-tracking tool and engage in self-directed PI practices within the context of stress management, we conducted a co-designed technology probe study by deploying *OmniTrack* [28], a mobile self-tracking platform that enables customization of personal trackers to meet individuals' various tracking needs.

The hallmarks of technology probes involve: 1) providing technological tools with users that may change their behaviors; 2) collecting data *in-situ* in a real-world setting through a probe; and 3) introducing an open-ended and flexible tool early in the design process to allow users to adopt a new technology in creative ways [21]. We chose *OmniTrack* as our technology probe because it is: 1) a self-tracking platform that enables self-tracking practices for different purposes, which often impacts individuals' behaviors [19]; 2) a mobile application that can be readily used to collect data about users in real-time at any place; and 3) an open-ended, flexible tool that allows users to create personalized self-trackers from the early phase of self-tracking practices. We did not choose *OmniTrack* because we believed it is the best form of technology for managing parenting stress, but rather because we viewed it as a research tool that would inform a future self-tracking tool for parenting stress management.

While previous research on technology probes mainly deployed a probe which is already designed by professional designers or researchers [21, 23, 50], the research approach of this study, inspired by co-design [46], gave participants more active roles in designing self-trackers by themselves for their own purpose with the aid of a facilitator. Following the approach of co-design, we position parents as the experts of their parenting experiences who can play co-designing roles throughout the design process, depending on the different levels of expertise and interest, within the context of parenting stress. Accordingly, the first author played a facilitating role and encouraged our participants to express their creativity at different levels by leading, guiding, and providing scaffolding throughout the study. Therefore, we let our participants brainstorm tracking topics related to their context of parenting stress with the aid of worksheets, choose individualized tracking topics among the brainstormed ideas by themselves, design custom self-trackers by defining different data fields for their purposes with the aid of a facilitator, and revise their trackers based on their first week experiences of self-tracking.

Participants

Since social isolation is a significant factor in parenting stress as presented in [53], we decided to focus on a specific population of parents who were living far away from family and friends, which was an ideal context to understand the isolation and vulnerabilities of parenthood. Capitalizing on the first author's proximity to West Lafayette, IN and fluency in Korean, we recruited five Korean mothers living in West Lafayette, IN—a small college town in the United States—who have a child younger than 36 months. Since we wanted to concentrate on the parenting stress that primary caregivers experience, we described the participation requirements as *primary caregivers of children younger than 36 months.* Though we never restricted the participation requirements to only mothers during the recruitment process, we ended up recruiting only mothers, who were in charge of primary caregiving roles as stay-at-home parents. All participants came to the U.S. with their spouses, who study or work in the U.S. Most of the them had one child whereas Jina (pseudonym) had three children. The participant demographics are summarized in Table 1.

Table 1. Participant Demographics

Name*	Age	Child's age	The length of time in the U.S.	Spouse's job
Dayoung	32	35 months	4 years	Graduate student
Jina	35	6 years 4 years 18 months	7 years	Working for a local company
Miyoung	35	17 months	2.5 years	Graduate student
Soojin	35	8 months	2.5 years	Postdoc researcher
Yumi	30	22 months	3 years	Graduate student

* Names are pseudonyms.

The purpose of this study was neither to verify the effect of self-tracking intervention on stress management nor to form generalizable theory about how new parents engage in self-tracking practices for stress management. Instead, we aimed to investigate the viability of using a self-tracking technology for stress management through an in-depth understanding of the self-tracking experiences with a focused set of parents who were physically isolated from family and friends. Thus, enrolling a small number of participants with the same cultural background was an intentional choice to foster effective interaction among participants and a researcher as design partners, as presented in other similar studies [56].

We solicited participants through a snowball sampling method [18]. We used this sampling strategy to recruit participants who were already somewhat familiar with each other because we wanted to create a comfortable atmosphere where parents can talk about their parenting experiences in a candid manner. In turn, all our participants were recruited through a local Korean church. The workshop was advertised as a research activity that could provide parents with opportunities to engage in self-tracking practices with the aim of stress management as well as to socialize with other parents. We lent each participant an Android phone with *OmniTrack* installed for the research study only because all our participants were iPhone users. The data entries were uploaded to a web server in real time if the phones were connected to WiFi.

Study Procedure

The study procedure consists of a series of interviews and design workshop sessions. Throughout two weeks, three design workshop sessions were conducted to: (1) co-design custom trackers; (2) revise the trackers; and (3) reflect on tracking experiences in a group setting. One-on-one interviews followed the second and the third workshop sessions.

In the first workshop, participants co-designed custom trackers in a group setting. Worksheets were provided to help partici-

pants reflect on their daily lives. These worksheets included fifteen scaffolded questions built on some of the concepts in the relevant literature (e.g. basic needs, social support, time for oneself, and parenting stressors). After brainstorming tracking topics with the worksheets, participants chose two to four tracking topics they desired. When choosing tracking topics, we asked them to choose 1) the most relevant topics to their parenting stress, 2) what they can record every day in the weekdays (weekends were optional), and 3) what topics they were interested in. Participants were also asked to write down their reasons for choosing their topics and what kind of data they hoped to gain about those topics. After creating custom trackers in *OmniTrack* (with the aid of the facilitator), participants presented their trackers to others.

In the second workshop, participants had a chance to revise their trackers based on their first week's experiences. Then, they were given one more week to use the revised trackers.

In the last workshop, participants were invited to share their tracking experience both in a group setting and in one-on-one interviews. We handed out worksheets to participants again to assist them to look back on their tracking experiences, which included what they learned through the tracking experiences and the impacts of the self-tracking on parenting stress management. One-on-one interviews were conducted to gain more detailed information about each individual's tracking experience, assuming some participants might feel more comfortable to share their experiences in a one-on-one setting. Note that the entire process of data collection was conducted in Korean to create a comfortable atmosphere for participants to speak in their native language.

Analysis

All the interviews and workshop sessions were audio-recorded and transcribed for analysis. Observational field notes for each workshop session were created to capture non-verbal communication among participants and the facilitator. The worksheets that participants filled out in the workshop sessions and the tracking data collected through *OmniTrack* during the two-week study were also included for analysis. All data were originally captured in Korean, and relevant portions of the data were translated into English during the process of analysis. Since the first and the fourth author are native Korean speakers who are fluent in English, we were able to cross-check the validity of the translation.

Structured data such as the worksheets and tracking data were analyzed through content analysis [5] for describing the characteristics of textual information. We also conducted a thematic analysis, following Braun et al. [6]'s approach, to find overarching themes across the loosely structured data, such as the transcripts and observational field notes from workshops and interviews. To become familiar with the data, we transcribed all the audio recordings from workshops and interviews. Then, we organized into tables: 1) what participants wrote down on worksheets; 2) what kinds of tracking topics our participants chose, how those topics changed over time, and rationales for those changes; and 3) each participant's tracking data. We then proceeded through an initial coding of the data, including translating the portions of the data we coded from Korean to English. We used a mindmapping tool to organize, generate, and iteratively revise overarching themes we saw through our initial coding, using example instances or quotes for each code to maintain alignment with our developing codebook.

As of one of the strategies to ensure the credibility of the study, we meticulously kept all the materials such as transcripts, observational field notes, worksheets, and usage logs and data from *OmniTrack* during the study process. We also used three approaches to increase the trustworthiness and reliability of the results: 1) methodological triangulation using interviews, observational field notes, workshop worksheets, and usage logs and data from *OmniTrack*; 2) peer-debriefing to check possible biases in attention and vocabulary; and 3) member checking, having participants review the findings to verify if we have reflected their perspective properly [7, 40].

Ethical Considerations

The study was reviewed and approved by our Institutional Review Board. We required informed consent for participation in this study from all participants. We informed our participants that their participation is completely voluntary, and they can pause or quit the study at any time without any disadvantages. Participants were also informed that the workshop and *OmniTrack* are not part of a clinically validated toolkit. They were strongly encouraged to create and customize their trackers as they desired to meet their own needs.

RESULTS

We present the findings of this study based on how our participants made use of a flexible self-tracking tool within the context of stress management and the impacts of the self-tracking practices on parenting stress management. We also present how engagement with the self-tracking tool—and with the co-design elements of this study—revealed certain parenting vulnerabilities.

Tracking Topics

Initial Choices of Tracking Topics

Our participants were interested in various stress management topics with *OmniTrack*, and Table 2 shows the range of topics the participants wanted to track. All participants wanted to track potential stress relievers, such as having free time by themselves, meeting friends, or exercising. Some of the participants focused on having a better understanding of themselves. For example, Soojin and Yumi wanted to understand how much they were stressed out, what made them stressed out, and if existing stress relieving strategies were effective through their trackers.

Four of our five participants chose to track topics related to their husbands such as *'Fun conversation with my husband.'* While there there was a question (1 out of 21 total) in the brainstorming worksheet that mentioned spouses, we do not believe that this overly primed our participants to include this topic. Dayoung, for example, wanted to measure how her husband was doing objectively through her *'Husband's involvement in parenting.'* With this goal in mind, she did not let her husband know that he was tracked because she did not want him to be affected by being aware of the tracking until

the second workshop. Jina wanted to have a better relationship with her husband through tracking time spent with him.

Revisions of Trackers

After one week of tracking with the trackers designed in the first workshop, participants had a chance to revise their trackers by changing their tracking topics and/or altering the kinds of data fields they were using. Three of our participants wanted to change tracking topics or add a new tracker as presented in the far right column of Table 2. Most of the changes resulted from new understandings they had already begun to develop about themselves while one was due to circumstantial reasons. Dayoung, for example, changed her *'Time for myself'* tracker to *'Time spent with my husband'* because she realized that spending time with her husband was more influential for her mental well-being. Unlike other participants, Miyoung made changes to her tracker because of circumstantial reasons. Because her son caught a cold during the study, she had to stay at home with him all the time, which made her not able to continue with previous trackers. Therefore, she and the first author talked and decided to add a new tracker, *'Baby naps,'* which was something she could track at home and meant some break time for her.

Also, some of our participants wanted to make some tweaks to their data fields because they came to have a better understanding of what kinds of data fields were more appropriate to know more about their topics of interests. Dayoung wanted to add a text field to describe the rationale of the rating for her husband's parenting because she needed one to find meaningful patterns after a few days of tracking. Miyoung wanted to change a time field to a time range both in her *'Going out'* and *'Exercise'* trackers because she felt a time range field made more sense to track the length of time that she spent time outside home or exercises.

Usage of Different Data Fields

How our participants made use of the data fields available to them through *OmniTrack* was of interest, especially how the combination of different data types impacted their self-tracking practices. Different data fields lent themselves to different kinds of insights. We will not argue that one data type was more influential than any other, but rather that the combination and option to include multiple types helped our participants engage in deep critical reflection about what they were tracking.

Time range

Most of our participants added a time range to their trackers to record from start and finish times of a certain event. Both Soojin and Yumi used this type of data to track when they slept and when their husbands took care of their babies. Through the data, Soojin and Yumi realized that their husbands were not spending much time with their babies, which made them frustrated. Miyoung similarly realized through tracking time range data that she spent very little time for herself and, instead, spent most of her time taking care of her baby.

Text

All participants used text fields in their trackers to describe something in detail. This type of data allowed participants to record what they did, what they felt, and why they felt that way. Dayoung, Soojin, and Yumi listed what kinds of things their husbands did while taking care of their babies with text fields. In addition, Dayoung described the rationale of her evaluation of her husband's parenting behaviors through it.

With the detailed descriptions of her feelings and the relevant contexts, Dayoung learned why she was sometimes dissatisfied with her husband: *"I thought how much my husband was engaged in taking care of our child was the most important factor for me. But, writing down the reasons for the rating, I realized I wasn't that satisfied even when my husband took really good care of our child for a long time because of other things, for example, when he went out to drink with his friends."* In summary, the act of writing through a text field allowed our participants to reflect on their daily lives.

Rating

Our participants utilized rating fields to rate their subjective satisfaction level. All participants evaluated their satisfaction of the quality time spent alone or with family and friends. To evaluate their satisfaction level, Dayoung and Jina included a rating field in their *'Time for myself'* tracker and Miyoung also included one in her *'Going out'* tracker. Through this type of data, Jina found out that her daily life was not as depressing as she thought: *"It was surprising that I gave 3 out of 5 stars even when I had a really serious argument with my husband. I thought I have been under a lot of stress, but I wasn't,"* which let her perceive her daily life more positively.

On the other hand, Dayoung and Yumi used a rating field to evaluate their satisfaction level of their husbands' involvement in parenting. Because Dayoung utilized a rating field combined with a text field for the rationale of the rating, she came to learn that she rated her husband's parenting very subjectively based on her feelings at the moment rather than how long he spent time with their baby.

Photos

Only Jina used a photo field in her trackers, which she added to her *'Time for myself'* tracker to keep records of what she did in her free time. In the first workshop, she expected that it would be easier for her to record what she did with photos than with text. In the last workshop, she reflected on her experiences and said that she enjoyed the act of taking pictures itself: *"It was really fun to take pictures of what I did for myself after my kids went to sleep even though they were just small things."* For her, the act of taking photos for personal records of daily events was perceived as a special and enjoyable moment.

Multiple-Choice

Our participants used multiple-choice data fields in creative ways. For her *'Time for myself'* tracker, Jina used multiple choice as a way of classifying what she did in her free time based on her preferences and feasibility. In the second workshop, Jina was unhappy with what she was finding in her *'Time for myself'* data, because all of her records involved her choosing her least preferred way to spend time with herself, *'having snacks or watching TV shows,'* rather than her most preferred way, *'shopping or hanging out with friends.'* However, after

one more week, she realized that she did not necessarily prefer *'shopping or hanging out with friends'* over *'taking naps'* and *'watching TV shows or having snacks'* because she found herself choosing to watch TV and have snacks even when she had a chance to go shopping.

Self-Tracking Practices and Stress Management

The two weeks of self-tracking practices had some positive impacts on managing our participants' stress, such as having a better understanding of one's life, discovering positive moments, and supporting data-mediated communication with their spouses.

Having a Better Understanding of One's Life

Through the two weeks of tracking, our participants gained better understandings about their daily lives. They learned whether their existing stress management strategies were effective. For example, Dayoung came to understand that spending quality time with family was far more helpful for her stress management than spending time alone, which surprised her. Therefore, she realized the need of modifying her current stress management strategies by focusing more on spending quality time with her family rather than trying to secure more alone time. Miyoung came to know that her existing strategies were very helpful for reducing her stress, especially meeting friends with whom she felt the most comfortable. Soojin found that she had been spending too much time on meeting friends outside and that she often felt tired as a result.

Even through just two weeks of self-tracking, our participants were able to recognize some patterns in their everyday lives such as lack of sleep or lack of outdoor time, which had negative impacts on stress management. These discoveries caused participants to resolve to improve on their patterns. Soojin and Yumi decided to go to bed early in order to not get too tired during the day. Miyoung resolved that she would go to the gym or take a walk more often.

Discovering Positive Moments

Even in a short time, the two weeks of self-tracking gave our participants a chance to discover positive moments of their lives. Most of our participants indicated that they realized, through their tracking data, they were in better situations than they had previously thought. Yumi and Jina found that their level of parenting stress was not as high as they thought it would be. Jina came to appreciate small things that she had been doing unconsciously such as having snacks or watching TV shows as she recorded such activities under the category of stress management: *"Even though I've had snacks almost every day, I didn't think I was doing something for myself. I just consumed snacks because I was stressed out without thinking carefully. However, recording it as one of the categories of 'Time for myself,' I came to realize this was also a precious thing to me, something that has a good influence on me."* Likewise, Soojin and Dayoung realized they were spending a lot of time for themselves on meeting friends or spending quality time with their husband though they had thought they were spending all day with their child.

Not only did they discover positive aspects of their lives, but they also came to appreciate what their husbands had been doing through the self-tracking. Jina, Soojin, and Yumi shared the same feeling that they had felt they were the only ones who sacrificed for their families, but they realized their husbands were doing their best for their family as well. Yumi said, *"When I first started tracking my husband, I almost felt I was taking care of our baby on my own because he only can spend a very short time with our baby. However, as I started to observe how he was taking care of our boy, I realized he has given 100% of his efforts at the given time for us."* Therefore, she came to feel grateful for her husband.

Table 2. Participants' Initial and Revised Tracking Topics

Participant	Initial tracking topics	Revisions of topics
Dayoung	Husband's involvement in parenting Time for myself	Time for myself ↓ Time spent with my husband
Jina	Fun conversation with my husband Time for myself Quite time	Fun conversation with my husband ↓ Communication with my husband
Miyoung	Going out Exercise	Added 'Baby naps'
Soojin	Husband's involvement in parenting Stress reduction strategies Sleep Frustration toward my baby	N/A
Yumi	Husband's involvement in parenting Going out Sleep	N/A

Supporting Data-Mediated Communication

Our participants wanted to better communicate with their spouses through the self-tracking experience. With tracking *'Time spent with my husband,'* Dayoung wanted her husband to cooperate with having quality time together. For Soojin, the self-tracking practice was an opportunity to collect data to facilitate communication with her husband to split parenting duties based on empirical data. She showed her tracking data to her husband and it helped him better understand her daily difficulties: *"I showed tracking data to my husband. He was shocked and felt sorry that I have lacked sleep and he didn't spend much time at home this week. So, we discussed what kind of help I need and how he can help better, then, he decided to stay home in the evening before our son goes to sleep."* Inspired by the tracking data, they were able to renegotiate how to split parenting duties, which was expected to help her relieve the burden of parenting and manage stress.

Parenthood Vulnerabilities

The two weeks of the study unveiled the lived experiences of new parents related to daily stress and the vulnerabilities of parenthood. Like many other parents with young children, our participants were struggling with stress in their everyday lives. Some of our participants, Miyoung and Jina, perceived their mundane routines of daily life as stressful. Miyoung stated that *"I realized my everyday life is really monotonous and repetitive, and I spend very little time for myself, especially, because my child has been sick recently; I have been tied to him all day long."*

Some of our participants were also unsatisfied with their husbands' involvement in parenting, which contributed to their perceived stress. Soojin's husband had been too busy, so he often got back home late at night and could not engage in

parenting much. In the second workshop, she felt tracking her *'Husband's involvement in parenting'* made the problems more prominent: *"I sometimes got mad looking at the data. I said to my husband, 'Honey, you only spent an hour and a half with our son today!', showing him the data."* Similarly, Yumi realized that the length of time that her husband engaged in parenting was too short, which made her feel she was taking care of her baby almost on her own.

On top of the struggles of being a parent of a young child, our participants were exposed to disadvantages as recent immigrants and trailing spouses, which is in line with prior work [63, 15, 48]. As all the participants were trailing spouses who came to the US due to their husbands' study or work, they had to take a leave of absence from work or quit their jobs before coming to the US—jobs which our participants described as 'fulfilling.' Therefore, they often found their dependence on their husbands challenging. For example, Jina had to quit her job right after she married her husband because her husband was working in New Zealand and then moved to the U.S. a few years later when her husband took a new job.

As feelings of isolation have been proven to contribute to the increased level of parenting stress [24, 33], our participants were concerned about feelings of loneliness. Miyoung, for instance, talked about the challenges of the life of an immigrant parent: *"I really wished that I could ask my mom to watch my baby for a few hours and have a day off to hang out with my old friends, but I have neither my mom nor my old friends here."* These examples illustrate the social isolation that our participants as immigrant parents experience.

Due to severe stress, some of our participants said they had worried if they had depression since they often experienced severe mental distress in their everyday life: *"I sometimes felt like I was going crazy when I had to take care of my baby all by myself for hours and hours even without a few minutes to have a cup of coffee. The feeling that nobody else—that I'm the only one who can take care of him sometimes really suffocates me (Miyoung)."* This instance displays the significance of the stress that new parents may experience in early parenthood.

Impacts of Co-Design on Self-Tracking Experiences

The co-design elements of the workshop allowed participants to be vulnerable with each other, providing a casual space for them to bring up their parenting struggles. While having conversations about their struggles, participants impacted each other's tracker design by actively giving feedback and suggestions. For instance, when Jina said that *'Fun conversation with my husband'* might be too pressuring in the second workshop, Dayoung recommended changing it to *'Candid conversation.'* Our participants explicitly mentioned that sharing their experiences in a group setting made them engage in deeper self-reflection. For example, Dayoung said she realized her husband spends a lot more time with their son that other husbands do while listening to others' stories in the group workshop; thus, she came to appreciate his efforts much more. In summary, the social nature of the workshop was considered beneficial for our participants.

However, some of the participants mentioned that they did not find the small group setting very helpful for making better self-tracking experiences because they felt that the tracking experiences had unique and personal meanings to them rather than common and social meanings. Yumi noted, *"I think the meanings of the self-tracking experiences would be different from individual to individual because all of us are in different contexts. I considered the self-tracking practice as a very personal activity because I've been interested in something that others wouldn't. It's significantly different from Instagram because I upload something that others would be interested in there."* In addition, the social nature could have led our participants to choose or not even to verbalize some tracking topics that they would have tracked on their own. For example, one of our participants mentioned that she would not have been comfortable tracking her sexual habits in this group, which we believe was due to self-regulation of sharing private and sensitive matters with others, which could be related to parenthood vulnerabilities as well.

Group Workshop as a Socializing Opportunity for Parents

The group workshops provided great opportunities with our participants to socialize with other parents having fun and escaping from a monotonous daily routine. Throughout the series of the workshop sessions, our participants found it enjoyable and fun to interact with each other. Particularly, unlike the first two workshop sessions, the last workshop was in the evening when the participants' husbands were able to watch their child. They were very excited to have an evening out without their child, especially Soojin, who had the first evening out after giving birth. Therefore, they brought food to the workshop to share with everybody, chatted for hours while we had one-on-one interviews in a different room, made jokes, and laughed with each other. We noticed how thirsty they had been for such socializing opportunity and how beneficial such an opportunity was for relieving parenting stress.

DISCUSSION

In this section, based on the findings of the two-week study of self-tracking for new parents, we consider the opportunities and challenges of parenting stress management of new parents. Next, we tackle how social self-tracking benefits or hinders the self-tracking experiences for parents' mental wellness. Lastly, we discuss the implications for group support program for mental wellness of new parents.

The Opportunities and Challenges of Parenting Stress Management

Managing Stress in the Daily Lives of Parents

The results of the study shed light on opportunities and challenges of managing stress in the daily lives of parents. Most of our participants chose to track the perceived satisfaction level of target activities and the rationale for the assessment. The perceived satisfaction assessment allowed our participants to learn that effective stress management strategies are not necessarily doing something special, spending time on one's own, or having a long break. Instead, doing small and simple things, spending quality time with family, or having a short break could be great stress relievers for parents. The results

indicate that parenting stress could be managed with just simple strategies that even parents who lack resources can easily implement in their daily lives. Accordingly, when designing a parenting stress management program for new parents, it can be helpful if a facilitator introduces some simple but effective stress management strategies that are readily available to them. Sending supporting reminders to take time for one's own health and wellbeing using such simple strategies, instead of notifications that could make parents feel bad about themselves or guilty [35], could also be of help for parents managing stress in their in daily lives.

In addition, it is notable that the rationale for the subjective appraisal was not necessarily based on the target activities or behaviors but often affected by other irrelevant or indirect factors (i.e., one's physical or emotional state or the satisfaction level of the family time). The results suggest that daily stress cannot be fully understood without considering the complex dynamics of one's daily life. Therefore, the complexity that influences daily stress perceived by individuals should be considered in designing stress management programs or tools.

The Role of Spouses in Stress Management

In designing this study, based on the relevant literature, we assumed that the most prominent stressors in parenting stress would include child behavioral problems or difficult temperament [29, 44] and social isolation [48, 33] and that the most effective mediators of parenting stressors would include intrapersonal resources of parents [22, 52, 64] and social support [30, 8, 54]. However, the role of one's spouse unexpectedly turned out to be significant in parenting stress management for our participants. In choosing tracking topics, our participants were passionately engaged in the conversation related to their spouses. Meanwhile, few participants engaged in active conversation related to their children when it comes to parenting stress. We posit that overwhelmed and stressed mothers found it more comfortable and less guilt-inducing to talk about their husbands compared to talking about their children. In other words, because mothers felt uncomfortable or guilty discussing their child negatively, they could have chosen their husband as a scapegoat to express negative emotions. This demonstrates a need for investigating ways to mitigate the guilt and shame of talking about the negative aspect of parenting in future studies. As presented in Ammari et al.'s work, pseudonymity can be one way to help parents overcome the guilt and shame and discuss sensitive parenting topics [4].

We found that spouses played roles both as the potential stressor and the effective mediator (directly or indirectly as scapegoat) of parenting stress. For some of our participants, dissatisfaction with their husbands' involvement in parenting contributed to increased level of stress, which is consistent with Nedleman's study of married graduate students [38]. One of our participants, Soojin, explicitly dealt with this problem by sharing her tracking data with her husband to renegotiate parenting duties, which turned out to be a successful approach for fostering her husband's empathy with her.

On the other hand, as fathers' involvement in parenting has been proven to lower parenting stress of mothers [39], our participants also emphasized how their spouses' involvement in parenting helped them when they were overwhelmed and exhausted by parenting duties. In addition, spouses' emotional support played a big role in parents' mental wellness [16]. Two of our participants aimed to promote their marital relationship by having better quality time with their spouse, so they asked for the cooperation of their spouses during the study. Other participants also emphasized the role of their husbands' emotional support in their mental wellness as it had helped them overcome the most difficult time after they became a parent. Interestingly, emotional support from one's spouse was considered more important than the length of the time that their husbands spent in parenting by our participants.

The great influence of spouse factors on our participants' parenting stress management could be partially due to the unique situations of the participants living as stay-at-home parents, recent immigrants, and trailing spouses. However, the impacts of spouses have important implications for studies related to parenting stress management. While many studies on parenting stress focus on the relationship between parenting stress and child abuse, more studies should deal with how a spouse's involvement in parenting or emotional support can support parental mental wellness. Furthermore, when designing interventions or tools for mental wellness, involving a spouse in the co-designing process as one of the critical stakeholders can have benefits in better-understanding the context of challenges and investigating better strategies to deal with those challenges.

Fostering Positivity through Journaling Practices

Prior studies have shown that journaling practices support people in dealing with negative thoughts and shifting to a positive mindset about oneself [60, 32]. Through the two weeks of tracking one's daily life as a parent for stress management, our participants' attitudes towards their lives changed in positive ways even without any circumstancial changes. The self-knowledge gained through the subjective evaluations of daily activities and others' behaviors enabled such changes. Learning about what kinds of resources and support are available to them and what kind of strategies work better for them, they came to perceive their daily lives more positively. Moreover, the PI practices were helpful for detecting negative patterns in one's thoughts and behaviors, which let our participants improve or resolve to improve.

However, the effects of writing about the causes of negative feelings are controversial. Some studies suggest it is beneficial for mental health [34, 41], but others have suggested that writing about negative feelings may result in higher levels of depressed moods [59, 58]. Our participants also mentioned how the tracking experiences negatively impacted their moods in the first place by making their daily struggles look more prominent (e.g., mundane daily routines, one's husband's less involvement in parenting). Accordingly, the potential negative impacts of tracking negative feelings should be considered when designing PI systems for supporting mental wellness of vulnerable populations such as new parents. It may be beneficial to provide individuals with some guidance to focus on problem-solving strategies in a concrete way instead of evaluating the emotions on an abstract level [59].

In conclusion, PI practices are well-suited to support individuals in dealing with negative emotions and having more positive perspective towards their everyday lives. However, the potential negative effects of journaling about negative feelings should be carefully considered when designing for vulnerable populations such as new parents. To that end, future research could investigate incorporating ways to help cultivate positivity in designing stress management tools by helping individuals find available resources and identify strategies that work better for them.

Social Self-Tracking for Parents' Mental Wellness

Developing Self-Knowledge

In line with the analytic framework of PI for mental wellness presented in [32], the findings of this study suggest that PI practices can be leveraged to support one's lifelong journey of finding oneself by allowing individuals to go through iterative cycles of developing self-knowledge. While recording and evaluating their daily activities from the perspective of stress, our participants were able to discover their own criteria to evaluate potential stressors, relievers, and other influential factors, which contributed to the expansion of self-knowledge.

Specifically, there was a benefit in providing a chance to reflect on and appropriate tracking experiences as participants revised their trackers with a flexible self-tracking platform. Even in a week, our participants were able to investigate what kinds of tracking topics and fields were more relevant to their contexts of stress. Therefore, when they were given a chance to revise their trackers in the second workshop, most of the participants were able to appropriate their trackers based on *"meta-self-knowledge,"* knowledge about how to gain more insightful and useful self-knowledge.

Thus, to support developing meta-self-knowledge as well as self-knowledge through PI practices, individuals need to be provided with opportunities to reflect on, monitor, and appropriate their personal trackers, which allows them to investigate more relevant topics and data fields that better suit personal needs. We argue that the iterative process of developing meta-self-knowledge and self-knowledge for managing one's mental wellness through PI practices can be facilitated through an *everyday design* approach [55]. The approach considers every individual as an everyday designer who incrementally and creatively appropriates artifacts and surroundings in daily life for themselves or their family to accommodate their daily needs [55]. Aligned with this approach, our findings indicate that parents, who are creative everyday designers, are capable of designing and appropriating individualized self-trackers in creative ways (e.g., collecting data to initiate conversation and support one's argument, keeping records of small but positive moments of daily lives) with the aid of a flexible self-tracking tool and a facilitator. Introducing the everyday design approach into the design of PI practices for supporting individuals' mental wellness has two potential benefits: 1) the approach can allow individuals to design self-trackers for their mental wellbeing in creative and unexpected ways, and 2) the approach is appropriate for supporting the everyday cycle of developing meta-self-knowledge and self-knowledge through continually appropriating self-trackers in daily lives.

Family-Centered Tracking for Supporting Mental Wellness

Our participants actively engaged their family members in their tracking experiences in various ways. The interconnectedness of the lives of family members let our participants choose to track their spouse's behaviors. When choosing their tracking topics, most of our participants chose topics related to their spouses such as their involvement in parenting or quality time spent with them, unlike what we expected based on the relevant literature.

Also, three of our participants let their spouses know that they were tracking topics about them and asked for their cooperation hoping that they could promote their marital relationship by having better quality time with their spouses through tracking such moments. Furthermore, one of our participants used her tracking data as a medium of communication with her spouse. She showed her tracking data with the hope that her husband could better understand her daily life, which turned out successfully. Because the data collected regarding one's daily parenting life helped open up the conversation, they were able to renegotiate how to split parenting duties.

Notably, there were interesting perceptions about tracking their spouses among our participants. They thought that revealing that they were documenting their husbands' behaviors could change the social dynamic between them either in positive or negative ways. Even though our participants perceived that tracking their spouses' behaviors was something that could be blamed in the first place, it turned out that their husbands did not feel offended by the fact that they had been tracked and even became more cooperative with their spouses.

Expanding the call for expanding the design lens from self-tracking to family-centered health tracking [42], we argue for the need for involving family members in the PI practices for supporting mental wellness. The design implications of this work on the family-centered tracking include: 1) the need to involve family members in the co-design process on different levels of engagement based on their needs and interests, ranging from being aware of what their spouse is tracking to making meanings of data together or to collaboratively tracking; 2) the need to facilitate communication between spouses by fostering empathy towards each other's daily life rather than proving one is right or wrong, or spying on each other; and 3) the need to consider or enable ways to better-express emotional support among those implicated in the tracking practices. Future studies could explore how PI can fit in to make parenting less stressful and the relationships between spouses more equal through explicitly and actively involving spouses in the co-design process.

Benefits and Barriers of the Social Nature of the Workshop

Consistent with prior work [32, 42], our findings indicate that the co-design elements helped facilitate the process of self-tracking experiences of individuals by allowing them to bring up their parenting struggles, gaining insights from others' tracking topics, exchanging feedback and suggestions with each other. The social nature of the workshop also allowed participants to engage in deeper self-reflection throughout the study. However, for some of the participants, the group setting could have put some constraints on choosing tracking topics

because of the personal and the self-regulating nature of individuals. We argue that the small group environment could work as an onboarding stop on the journey of self-tracking experiences for stress management as it facilitates the process of designing self-tracking experiences. Following the self-tracking practices in a group setting for a few weeks, individuals may engage in self-tracking respectively, without any concerns about privacy or social reputation. In this way, our participants might move on from *"social self-tracking"* to more traditional, individual self-tracking. This transition from social to individual self-tracking could provide precisely the kind of onboarding experience that is required for flexible self-tracking systems.

Implications for Group Support Program for Mental Wellness of New Parents

As previous studies on parents indicated [43, 53], the findings of the study shed light on designing a study or a group program to support mental wellness of new parents. First, the purpose of the meeting should be for parents, not for their children. Many parents with young children engage in play dates, the purpose of which is for their children. However, even though such meetings for children provide socializing opportunities for parents as well, parents may find it difficult to engage in candid conversation to freely talk about their struggles as a parent in such meetings if their purposes are not for parents. Accordingly, when designing a study or group program for the mental wellness of parents, the purpose of the meeting should be explicitly advertised as 'for parents' instead of 'for children' to let parents be aware that talking about their parenting struggles will be accepted and welcomed.

Second, it is crucial to create a casual and friendly atmosphere for helping participants discover common ground between each other. We posit part of the reason that our participants were able to become close to each other in such a short time was that they had many things in common, such as nationality, child's age, religion, status as immigrants and trailing spouses, and even spouses' jobs. Therefore, they found it easier to find the source of conversation, open themselves up, and empathize with each other. For new parents, despite many differences in cultural or social backgrounds, there is an opportunity for discovering common ground easily based on the age of one's child, which makes it easier to begin a new friendship. This common ground helps open up a new opportunity for the social life of new parents.

Limitations

This research is limited by the following:

- This study was conducted with relatively few participants, which will not represent the entire population of parents. However, our goal through this study was not to generate generalizable findings but rather to begin to develop an in-depth, pragmatic understanding of the impacts these PI practices could have in this specific context.
- Though we never restricted the participation requirements to only mothers, our participants were all mothers who were playing the role of primary caregiver. To mitigate this limitation, in the discussion, we sought to provide implications that are applicable to both mothers and fathers. However, as stay-at-home fathers have distinct challenges associated with traditional stereotypes about gender roles and responsibilities [4], in future studies we acknowledge that we need to find a productive way to identify fathers who serve as primary caregivers of their children and investigate how flexible PI tools can support diverse families.
- This study took place in a single city, West Lafayette, Indiana, in the United States. Therefore, the findings of this study may not be generalized to parents from other cities in the United States or other countries. Also, since all participants were Korean immigrants living in the United States, the findings might be influenced by Korean culture. The implications of this are outside of the scope of this paper.
- The two-week deployment period might have been too short to confirm the effects of the self-tracking practices on stress management. This period also included the time needed for participants to adapt to the *OmniTrack* application. To mitigate this limitation, we had a training activity session to ensure if they understood how to use the application.
- The researcher may have cultural bias or assumptions that might have affected the data collection or analysis. To mitigate this limitation, we had our peers from multiple cultural backgrounds check for possible cultural biases.

CONCLUSION

This study explored how new parents make use of a flexible self-tracking tool through a two-week deployment study of co-designed, individualized self-trackers for stress management. The findings of the study showed some simple but effective stress management strategies that can be readily employed in the daily lives of parents, the influence of spouse factors on parenting stress management, opportunities and challenges of fostering positivity through journaling practices. This work also provides insights into the field of PI including how flexible self-tracking practices can support developing self-knowledge and fostering positivity, how PI practices can facilitate communication for supporting mental wellness of family members, and the benefits and barriers of group workshops on PI practices for mental wellness. We also discussed how group workshops can benefit parents' mental wellness by providing socializing opportunities for parents.

Through this study, we have demonstrated how flexible self-tracking tools can provide a novel way to support the mental wellness of new parents. We argue that more work in this area, particularly with regards to how to introduce and train new parents to use flexible self-tracking tools, can benefit parents' abilities to manage their own stress and mental wellbeing.

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