The Lived Experience of Child-Owned Wearables: Comparing Children's and Parents' Perspectives on Activity Tracking

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ABSTRACT

Children are increasingly using wearables with physical activity tracking features. Although research has designed and evaluated novel features for supporting parent-child collaboration with these wearables, less is known about how families naturally adopt and use these technologies in their everyday life. We conducted interviews with 17 families who have naturally adopted child-owned wearables to understand how they use wearables individually and collaboratively. Parents are primarily motivated to use child-owned wearables for children's long-term health and wellbeing, whereas children mostly seek out entertainment and feeling accomplished through reaching goals. Children are often unable to interpret or contextualize the measures that wearables record, while parents do not regularly track these measures and focus on deviations from their children's routines. We discuss opportunities for making naturally-occurring family moments educational to positively contribute to children's conceptual understanding of health, such as developing age-appropriate trackable metrics for shared goal-setting and data reflection.

CCS CONCEPTS

• **Human-centered computing**; • **Empirical studies in ubiquitous and mobile computing; Mobile devices; Empirical studies in collaborative and social computing**;

KEYWORDS

Health-Wellbeing, Personal Data/Tracking, Children/Parents, Wearable Computers

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1 INTRODUCTION

Wearables, like activity trackers and smartwatches, have become increasingly popular among children in recent years. As of 2019, the market value of the child-oriented wearable industry was $350 Million [16], which even excludes wearables designed for adults but owned by children. Parents introduce some of these wearables to children without any chronic health conditions hoping they can develop healthy habits through self-tracking of physical activity, potentially leading to long-term physical health and wellbeing [47]. Studies have looked into individual use [41, 43] and collaborative use (co-use) [29, 54] of child-owned wearables. Among these previous studies, the ones that investigated the use of commercial wearables either collected data with introducing wearables as an intervention [29, 59] or reported results on naturally adopted use from a single perspective, mostly parents [47]. We know relatively little about children's perspectives on naturally adopted commercial wearables, which is important for understanding how they experience the wearable's strategies for promoting long-term health. Understanding how children's and parent's experiences with wearables align and differ is particularly important because children and parents often have different perspectives on technology use [8, 27].

Drawing on past work on the individual [18, 20] and family [40, 49, 54] experiences with self-tracking technologies in everyday life, we aimed to understand the lived experiences of wearable use for activity tracking (beyond health requirements) in family life. We examine similarities and differences in the perspectives of children and their parents in families who adopt child-owned wearables on their own. Understanding people's experience with current tools provides insights into the strengths and limitations of activity tracking wearables, absent influence of researcher observation or emphasis on the evaluation of introduced features. In exploring the use of child-owned wearables in family's everyday life, we aimed to answer the following questions: 1) What are children's and parents' motivation for adopting child-owned wearables in the family setting? 2) How are child-owned wearables used by family members in everyday life?

To answer these questions, we interviewed 17 families (19 children and 18 of their parents) who adopted child-owned wearables naturally. Our findings indicate that children and parents have different expectations for wearables. Children cared more about having fun by achieving high step numbers and comparing them with or competing against their family or friends. Conversely, parents expected wearables would assist their children in developing consciousness about the value of being active and hoped their children would develop long-term healthy habits as a result of being more aware. However, co-use practices are mostly structured around children's motivations and promoting daily physical activity, but less towards developing children's health awareness via joint media engagement.

Our work contributes to research on personal informatics and family informatics by 1) exploring children's and parents' motivational differences for the use of child-owned wearables and their impact on individual and collaborative use, and 2) describing opportunities for further parent-child engagement around goal-setting and data reflection.

2 RELATED WORK

Our findings build on the practices of personal informatics and family informatics, particularly on children and family's use of wearables. These use practices show similarities with parent-child interaction over other technology types and media that describe the significance of parental mediation and joint media engagement for child's informal learning.

2.1 The Practice of Personal Informatics and Family Informatics in Family Life

Personal Informatics, or how people track and visualize personal behavioral information such as health data and physical activity, has been widely studied in HCI. Researchers have aimed to build a holistic understanding of how people collect and reflect personal health data together with their motivations for this practice [20, 35]. While many people track for the purpose of self-improvement, understanding people's everyday experiences with self-tracking technology has surfaced alternative motivations such as tracking out of curiosity, a desire to collect a record of past activities, or purely for enjoyment [18, 20, 52]. People frequently use the same personal informatics technologies to support different motivations. People's motivations for using tracking technology often evolve over time and can result in abandonment or lapsing [20, 46]. Researchers have explored strategies (e.g. goal-setting) to further encourage physical activity and sustained practice of self-tracking [15, 44].

Although personal informatics has typically examined the tracking habits of individuals, research is increasingly examining collaborative tracking practices including the joint collection of data and collaborative reflection in family contexts [19]. Pina et al. investigated how families collaboratively approach self-monitoring, self-management, and self-tracking of health data [49]. While family members jointly develop goals in line with health guidelines and distribute tracking burden across the family, barriers to self-tracking have ripple effects between family members. Although tracking as a family can increase each member's awareness of the experiences of the others [11, 26, 50, 51], it can also introduce boundaries or divisions when tracking challenges family structure or order [26, 29, 50, 61].

Past studies have sought to understand how children and parents co-use technology to manage family health [49, 50, 53, 54, 57]. Researchers have investigated how technology can initiate conversations and reflections around healthy living practices (e.g. activity, diet, sleep), promote a healthy lifestyle through competitions, increase interaction and bonding opportunities between family members as well as help families build awareness and set goals [36, 39, 53, 58]. Child-owned wearables with activity tracking features have been reported to have positive impacts on those issues in family life [40, 54].

Resembling how Garg and Moreno describe domestic use of internet-of-things (e.g., smart speakers), child-owned wearables are not limited to individual use but serve as an "*inherently shared*" technology in families [22]. The majority of wearables combine a wearable device (typically a wristband) and an app operated through a smart device (most often a smartphone) for collecting, storing, and viewing tracked data. The use of child-owned wearables is therefore a family practice because many younger children are not smartphone owners. Thus, parents need to introduce activity tracking to children and usually have access to and sometimes control of children's activity tracker's app [25, 40].

Researchers have specifically explored and evaluated opportunities for co-use of wearables in families. Features such as gamification [57], collaborative reflection on data [55] and comparative visualization of data [50] have sought to bring parents and children together to collect and reflect around tracked physical activity. These design strategies have introduced parent-child interactions around tracked data, family challenges, and comparisons among family members, creating opportunities for family bonding and health awareness [53] and enabling family health management [49, 50].

However, these family co-use strategies are not fully supported with current commercially-available wearables as many of them are designed for adult's individual use [25]. Different from adult users, younger children tend to have a limited understanding of the data generated by wearables and tend not to know the potential positive impact of physical activity on their health and wellness [1, 43, 51]. Children's interest in and continued use of wearables can be socially influenced, such as whether their friends [41] or others in the household [47] have similar devices. Children are also motivated by social rewards that are designed to initiate their interaction with their parents, fulfilling children's need to connect with their parents [53]. These motivations and the need to assist children about the meaning of data require parents to mediate child-wearable interaction [47].

2.2 Parental Mediation for Children's Informal Learning via Technology and Media

Parents practice different strategies to mediate children's engagement with technology and media including restrictions, active/instructive mediation, and collaborative engagement with technology and media [28, 38, 63]. Different mediation strategies adopted by parents can have distinct impact on children and parent-child interaction [23, 28, 45].

A lack of parental mediation, highly restricted parental mediation, or failing to address children's perspectives on technology use in family life can result in tension within the family [8, 17, 24, 45]. Some parents favor restrictions of technology use and work out rules to regulate their child's interaction with technology and media and decrease the negative impact of technology and media [45, 63]. These rules can include limitations towards approval, duration, context, content, and time of use [27, 28]. For instance, Hikiner et al. [27] highlighted that parents expect their children to set aside technology at certain times and not to perform certain actions. Ghosh et al. [24] reported that parents adopt parental control mobile apps hoping to create a safe online environment for children.

However, technology and media are also known to have positive impact on children [13, 23]. This understanding yield parents to practice "*positive regulations*" [37] and create possible learning opportunities for their children. Parents who prefer active mediation discuss issues (e.g. content) related to technology and media, hoping their children to develop critical thinking skills through discussions [42]. Some families do not favor regulations but practice "*joint media engagement*" [60] in order to enhance the positive impact of technology and media on their child's learning and cognitive development.

Through joint media engagement such as co-use, co-play and co-viewing, parents not only have a chance to assist their child's technology/media use but can also influence and support their child's informal learning through experiencing technology/media together with their children. For example, Barron et al. [6] identified seven parental roles when exploring how parents mediate their children as they create new media. As parents become children's learning partners through joint media engagement, they can enhance participatory learning with their children [13]. This participation can also provide playful learning opportunities for children [13]. Such technology/media enhanced gamified experiences also positively impact children's engagement with technology and learning [21, 31].

Growing use of mobile technologies such as wearables define further opportunities for children's formal and informal learning. While studies that explore wearable use for children's learning are still limited [21], there is evidence of the potential for wearables to provide learning opportunities for children. Garcia et al.'s study [21] explored smartwatch-enhanced learning of science to support students in developing situated reflection skills. Their work shows the potential for wearables to help students explore science concepts within the context and experiences of their everyday lives. Some scholars explored the possibility for wearables to enhance embodied learning, leveraging sensors that convert body movement into visual/audio output [10] to help children develop tacit and explicit knowledge through body movements [34], allow children to learn while playing [31] and relate their movements with statistical reasoning [33].

We built upon this prior work from health informatics and learning sciences to further explore the experiences around child-owned wearables for activity tracking in an informal "*learning ecology*" [4, 5], namely the family. The adoption of child-owned wearables in families impacts both children and their parents, thus it is important to understand both of their perspectives regarding child-owned wearables. Our study extends the knowledge from previous family informatics studies by differentiating how children and parents perceive child-owned wearables differently, and how the differences shape their use of such technology. Our study also defines opportunities for structuring parent-child co-use and raising children's health awareness.

3 METHODS

To gain an in-depth understanding of how child-owned wearables with physical activity tracking features are currently being used by families, we conducted semi-structured interviews with 17 families. Following recommendations from family research literature [2, 3], we conducted interviews with parents and children simultaneously to observe the discussions between parents and children around collaborative use and to bring up potential disagreements around use or motivation.

3.1 Data Collection

We recruited families with children who were currently using a wearable device for tracking their physical activities at the time of the interview. At least one child and one parent from each family were asked to be present at the interview. We decided to restrict participation to children between the ages of seven to twelve who were using wearables and their parents, as previous studies have suggested the significance of this age range for the development of health awareness and family health management [7, 14]. We asked the parent who was more active in the management or use of child-owned wearables to participate in the interview.

To recruit participants and deem their eligibility, we posted a screening survey to the author's Facebook feeds, multiple parenting Facebook groups, parenting subreddits, and some subreddits associated with U.S. cities in June 2020. While 49 people filled out the screening survey, only 15 responded to our initial contact. To increase the number of interviewees, we adopted snowball sampling and recruited two more families. Among all recruited families, two had two children who participated in the interview with their parents, and one had both parents participated in the interview with their child. In total, we interviewed 17 families, representing 18 parents and 19 children. Table 1 lists participants with their information.

The majority of the parent participants self-identified as mothers (15 of 18), with three parent participants as fathers. Child participants were more split (ten sons, nine daughters). Parent participants described their child participants as healthy, with no chronic medical conditions or requirements. Our participants had relatively diverse racial backgrounds and family structures. Among the 17 families, seven were Caucasian, four LatinX, four mixed-race, and two African American. Three families were single-parent households. Fifteen families had one or two children, one family had four children, and another had six children. Parent participants' occupations included nurse, lawyer, researcher, full-time parent, IT consultant, teacher, personal assistant, and project manager.

In total, children used 12 different models of wearable devices with physical activity tracking features. Five models indicated in their marketing material (e.g., online product pages) that they are specifically designed and branded for children; we asterisked these models in Table 1. The remaining seven models did not indicate that they were specifically designed for a certain group of users. Overall, the wearables that were specifically designed for children tended to differ by having a smaller interface and wristband size, and include fewer kinds of health data available to track. Some children-oriented wearables tried to attract children with colored

Table 1: Overview of study participants

ID	Parent	Child	Child's Age	Child's Wearable	Duration of Use of Current Wearable
1	Mother	Son	7	YAMAY	3 months
		Daughter	11	Fitbit Versa	10 months
2	Mother	Son	8	H Band	3 months
3	Mother	Daughter	12	Apple Watch Series 3	24 months
	Father				
4	Mother	Son	11	Fitbit Versa 2	7 months
5	Father	Daughter	9	Fitbit Versa	12 months
6	Mother	Son	11	Fitbit Ace *	12 months
7	Mother	Son	8	TrendyPro *	3 weeks
8	Mother	Daughter	7	Fitbit Ace 2 *	1 month
9	Mother	Daughter	10	TrendyPro *	6 months
10	Father	Daughter	10	Fitbit Charge 2	8 months
11	Mother	Daughter	12	Apple Watch Series 1	12 months
12	Mother	Daughter	7	TrendyPro *	7 months
		Son	9	H Band	5 months
13	Mother	Son	8	Vtech DX2 *	24 months
14	Mother	Son	8	Fitbit Ace 2 *	7 months
15	Mother	Daughter	7	GARMIN Vivofit Jr 2 *	2 months
16	Mother	Son	11	Fitbit Charge 2	1 month
17	Mother	Son	9	Fitbit Charge 2	1 week

straps (e.g. Trendy Pro), interfaces with child-friendly characters (e.g. Fitbit Ace 2) or gamified experiences (e.g. Garmin Vivofit Jr 2).

All child participants were currently using the wearable at the time of the interview, with the shortest duration of use being one week and the longest being 24 months. Overall, 14 of 19 child participants had used the device for 3 months or more, with a median duration of use of 8 months.

All 17 interviews were conducted by the first two authors together. One interviewer primarily asked the questions while the other took notes, asking follow-up and clarification questions. Our interview questions focused on the following four aspects: 1) child's introduction to wearables and the family's past experiences with wearables, 2) parent's and child's motivations of using child-owned wearables, 3) parent's and child's positive and negative experiences of using child-owned wearables, 4) the impact of wearable use on family's everyday life and health. We kept the interview questions consistent across the children and parents while adapting the specific phrasing of certain questions to make them more accessible for children to understand. Although parents and children were interviewed at the same time, we asked questions individually to children and parents to make sure that we obtained the perspectives from both stakeholders. We also made note of the interactions and conversation between the parents and the children during the interviews, which added another layer of nuance.

We originally planned to interview participants at their homes as a more natural environment for children to express themselves, however, due to the COVID-19 pandemic, we conducted all interviews online through Zoom. All interviews lasted between 50 and 60 minutes. We audio-recorded all interviews with participants' permission and compensated each family with 25 U.S. dollars for their participation. IRB approval was obtained prior to data collection.

3.2 Data Analysis

The interview data were transcribed and analyzed inductively [48], following Braun & Clarke's thematic analysis method [9]. After the first ten interviews, we conducted a preliminary analysis, defined areas that we needed to collect more data, and refined our interview questions accordingly. For the rest of the study, we conducted interviews and analyzed the collected data simultaneously. We reached theoretical saturation after the fifteenth family, but interviewed two additional families to make sure we collected sufficient data. In the final analysis, we first re-read the interview transcripts and the first two authors open coded the data individually. All four authors met weekly to discuss the codes until no new codes emerged. We focused both on the perspectives of wearables at the individual (children and parents) and collaborative (family) level and grouped our codes under higher-level categories in relation to motivation, use, and data interpretation.

As we study physical activity tracking in families with children using wearables, in the next section, our reported findings and themes primarily surround children's and parents' physical activity tracking experiences regarding the child-owned wearables. We limit our results to the use of wearables within families and do not share results about use among friends, at school, or with others or in other environments.

4 RESULTS

Family's experiences with their child-owned wearables were somewhat influenced by what the device was able to track. Each wearable enables slightly different tracking metrics, with the most common ones being steps, exercise, sleep, distance traveled, and reminders. Among these features, children's engagements with wearables were primarily centered on activity tracking, in particular, step counts.

16 of the children used the wearable primarily to track their daily steps. A few children occasionally checked sleep data, distance traveled, blood pressure, calories burned, and route traveled.

Among the 12 wearable models used by our participants, only one did not have an accompanying app. The app's primary goal is to access the tracked data and they are used by children themselves if they own devices (e.g. smartphone or tablet) or by their parents. 10 of our children participants had smartphones, but only half of them had the app installed on their devices. In total, 8 apps were installed and used on devices primarily used by their children, 8 on devices primarily used by parents, one on multiple devices, and one family did not have the app installed on any device.

For the remainder of our findings, we describe family's use of wearables for activity tracking, primarily focusing on their use of tracking steps. We focus on motivations and use, introducing children's and parents' perspectives separately, and discussing instances of collaborative use. When quoting participants, we reference children as C, parents as P, and families as F. When more than one child or parent participated in an interview session, we add a decimal number to differentiate them (e.g. the first child in F1 is C1.1, the second child C1.2). If not stated otherwise, we use the term "*wearable*" to describe child-owned wearables with physical activity tracking features.

4.1 Motivations towards Child-Owned Wearables

While both children and parents indicated that they ultimately relate activity with health, their motivations behind the daily use of wearables were not always structured around daily activity goals. Children primarily used wearables for having fun by achieving high step counts and comparing or competing them with their family or friends. Conversely, parents expected wearables to develop the value of being active, and they hoped their children would develop a healthy lifestyle in the long run. In this sense, children and parents had different expectations for what wearables would promote.

4.1.1 Children's Perspective – Being Active for Fun. Children participants typically defined having a wearable and tracking activity as "*fun.*" For most children, having fun was more important than the numbers tracked through wearables. The following conversation between a parent and a child exemplifies this situation:

> P1: "*What do you think about your steps data and your activity data?*"
>
> C1.2 (11 y.o.): "*Doesn't matter that much, it's just fun to check on.*"

When we probed children more on the fun moments they had with their wearables and what they meant when they describe wearable as fun, their answers highlighted two types of motivations, one being self-oriented, and the other being defined based on others. Their self-oriented motivations were mostly structured around the excitement that comes with accomplishments. Children enjoyed seeing changes in numbers with their activity. In general, children were aiming for numbers to "*fly up*" (C7, 8 y.o.). Only in one case, a child (C9, 10 y.o.) aimed to decrease her amount of activity, as she was observing the changes in her blood pressure during and without activity. In general, children, like C12.2 (9 y.o.), shared their fun experience as being the time they reached their highest step counts or activity total "*I first got the . . . [H Band] when I was at school, I got 29,607 . . ., my record before that was 18,001.*" The technology that is attached to their wrists "*encourages to be more, to get higher*" (C9, 10 y.o.). Another child explained: "*I just want to get higher than the last time I did*" (C15, 7 y.o.). As step totals can always increase, we asked children if they have an upper limit for the number of steps they wanted to walk. None of the children set an upper limit for their daily steps. We found children often perceived their daily steps as similar to other games they have played. They aimed to reach higher points and surpass their highest scores, seldom relating the numbers to their overall health. However, later in the interviews, some children defined how they relate health with physical activities: "*Healthy means to stay active all the time*" (C11, 12 y.o.). They perceived having wearables as a way to become healthier: "*By wearing this, I can check how many steps I have, and I can assume that I've been getting a little healthier*" (C7, 8 y.o.). These can be interpreted as children also having intrinsic motivations to use wearable for being healthy without understanding the meaning of reported data.

Children's statements further explained that they associated higher numbers with a sense of accomplishment that comes with reaching goals. C3 (12 y.o.) said, "*I feel excited that I reached my goals and then reach more goals and then I get higher and higher.*" C17 (9 y.o.) particularly appreciated how his wearable celebrated his accomplishments, adding, "*I think I would just wear it because I like how, at the end when it says, 'You have 10 thousand steps,' it'll do a little disco ball and then it'll celebrate.*"

Children's motivations that depended on others mostly occurred through the interactions enabled by their wearables. The most common practice for this type of motivation was comparing step counts and competing with parents, siblings, and friends. We observed two main motivations behind these activity challenges. First, some children saw these activity challenges as a game: "*We like to run around and see who gets tired out and can't run anymore and then you see how many steps we've done in that period of time. And then we all do it and we all pick and one of us, whoever did the most steps in that amount of time wins. And sometimes we'll do a timer where we will know how many steps we can do in the timer*" (C9, 10 y.o.). Second, some children were more competitive in nature. P15 explained her younger son, who also owned a wearable, has become more competitive and was concerned about data more than C15 (7 y.o.). C16 (11 y.o.) explained checking a shared leaderboards with his mother and relatives who are geographically apart to see "*how many steps I [he] need[s] to beat someone*" and shared a memory in which he spent the whole day on a treadmill to win in the challenge.

4.1.2 Parents' Perspective – Building Health Awareness. Parents' comments reflected their goals of having a long-term impact on their children's health by making activity a part of their daily routines. Parents described nearly all of their children participants as either active (15 children) or very active (3 children): "*Seeing that they are really active. I think we don't have any concerns there about them not getting enough activity or anything*" (P12). Although parents did not introduce wearables to their child because they felt they were inactive, they all hoped for their child to become more active or continue being active, relating these directly with long-term health. For example, P14 said, "*my main goal is for him to be active and stay active . . . It's very important for his health.*" When being asked to describe what health for a child means for them, parents mostly commented on being active, getting outside, and eating healthy food, finding wearables valuable for supporting the first two of these concepts. With the use of wearables, parents were "*just making sure that she [the child] is moving and staying active*" (P8). For this goal, parents valued wearables as a "*motivator*" (P11) to keep children active: "*. . . even though she's young, making sure she stays active in some type of way*" (P11).

For parents, the desire to keep children more active and staying active was partly related to contemporary lifestyle changes related to an increase in indoor activities structured around screens: "*now it's more common for kids not to play outdoors. I kind of want him to have the same as when I grew up. We didn't have electronics; we were always outside. So, I want that for my kids*" (P14). Parents described how their lives depend on a structure, and how this structure was instrumental in family life: "*we have . . . counted on the structure of our lives to sort of deal with things*" (P7). Parents expected that wearables would either support or build a new structure by getting the child to manage their health for themselves. P9 explained that the wearable encouraged her daughter "*to take an active role in being active.*" P16 had a similar goal: "*it's not just to be telling him to do it, but then he'll enjoy it, and then just continue it on his own.*" Thus, wearables took some pressure off the parents as they structured children's activity by reminding the child (and the family) to stay active and made exercising appealing: "*It makes another reason that being active is cool and they're excited about it*" (P12). Parents observed that by using wearables, their children were "*more willing to be active*" (P15).

Although parents tried to motivate their children to be active, they also did not want them to be overactive: "*I told him, 'Hey, you don't need to actually go around the block and walk. If you just play your normal sports that you do per day, then you're going to hit the steps that you need'*" (P17). Parents believed in the balanced use of wearables. A parent explained preventing her daughter from using the wearable if she thinks her daughter was becoming overly concerned about the data: "*Sometimes she gets a little bit obsessive about the number of steps on it and we kind of have to take a break from it and just be like, 'Okay we're not going to wear it today'*" (P8).

Parents' ultimate motivation for increasing their child's attention to physical activity was often to encourage their children to consider their long-term health and wellbeing. Parents want their child to be "*more self-conscious. . .more mindful*" (P14) of their activity level. P9 explained that the wearable "*encourages awareness of activity and that's what I think is the biggest thing is that awareness of activity and what we're doing.*" P8 made a similar statement: "*The wearable is more to kind of enforce the idea of being health conscious.*" Thus, parents adopted wearable devices to help their child build healthy habits around exercise and eventually have a long-term positive impact on their lives. P15 described their motivation as, "*[I] definitely want my kids to have, like, active be more of a lifestyle where they're, like, just not lazy bums.*" P8 agreed, adding "*I want to build habits that are going to last her lifetime, for her to have a healthy, long life. . . I'm trying to build good habits that are going to last her life.*"

4.2 Use of Wearables by Children, Parents, and Family

Participants' comments supported past literature that the use of wearables is not limited to the children's individual use [25, 54]. Parents occasionally monitored their child's tracked data to assess their child's activity level. Parents and children also collaboratively used wearables to compare, compete, and discuss activity data.

4.2.1 Children's Interaction with Wearables. In daily use, children mostly defined a physical activity goal and aimed to reach that goal: "Because it has a goal to it, and then you set a goal. Like, if you want to burn some calories or something more. Or run, and you don't know your limit or something, you put the limit on here. Then, you run to that limit, and you've reached the goal" (C11, 12 y.o.). Like C11, children's goals were often not the default 10,000 steps. This is partly because some children did not understand the large numbers and the meaning of step counts as reported through the wearables. We asked all children to identify their daily step goals. Twelve reported a numeric goal, the rest either did not define or describe getting higher as a goal. Five children had a number between 1,000 and 10,000 steps as their target, four children had 10,000 steps. But not all of these children were able to explain why they have this number as their target. A parent (P14) reported her child picked 10,000 steps as the daily goal to mimic her own goal of 10,000. Some children reported their daily step goals as 112 (C8, 7 y.o.) and 500 (C6, 11 y.o. and C9, 10 y.o.) steps.

These findings indicate that children participants liked setting up goals to achieve, but they were less clear about what the numbers mean. Consequently, these children depended on other strategies for goal-setting. Some children aimed to have more steps than their parents or friends, while others aimed to beat their highest totals or defined an activity-oriented goal: "*set time goals . . . I can see how long I do exercise*" (C1.1, 7 y.o.).

In general, children mostly checked their data during times when they were active, especially when they were exercising. They reported enjoying observing the change in numbers as they moved. An 11-year-old explained: "*I feel like I get more steps when I'm at school, so on the weekday, but then if we go hiking on a weekend then it would make a difference*" (C4, 11 y.o.). C17 (9 y.o.) mostly wore the wristband during weekdays because he competed in step challenges which took place from Monday to Friday. He considered weekends as free of activity tracking, saying "*The weekend is kind of like my chill, where I could just sit on the couch*". These indicate the children's tendency to have an activity-oriented use practice for wearables, which is instrumental in children's data reflection and goal-setting. For instance, by comparing and reflecting his previous steps data, an 8-year-old learned what should be an ideal step to target himself: "*If I don't go on a hike, [I usually have] 5,000 steps, but mostly if I go on hikes in the morning, [I will have] 8,000. Because I mostly hit those goals if I'm in those situations*" (C7, 8 y.o.).

Children commented on the wearables' role in helping them to be more active daily. A 12-year-old (C11) explained checking how many steps she walked when feeling inactive and seeing low step counts motivated her to move more: "*it really motivates me to run more and exercise more.*" However, if the step count is much lower than the child's goal, they would often forego the goal for the day. P5 described, "*I notice that if she's close to the ten thousand steps, she* *moves a bit more. But if she hasn't moved as much during the day, she doesn't care to get the ten thousand steps.*"

These use practices mostly illustrate that children check and reflect on data during the same day or right after an activity. Only two children reported checking their weekly data. As explained by a mother (P8) of a 7-year-old, other children did not reflect on their weekly data: "*She checks on the data when it's on her wrist, she doesn't necessarily care about the data over the course of the week, like I do. She mostly is into checking it right in the minute.*" These use practices indicate children's focus on instant gratification. They cared more about their present activity and mostly monitored how it changed over the duration of an activity. Children's focus on instant gratification and wearables' inability to motivate some children during inactive times was also evident during the extraordinary times of our study. A 10-year-old changed her daily steps goal during the COVID pandemic: "*I see that my steps are very diminished in the day . . . Much lower, and I change the steps that you need to do from 10,000 to 5,000*" (C10, 10 y.o.). A parent further described lower use of the wearable during the pandemic as they did not go outside as often as before: "*feel less excited about the watch in the sense that we [they] can't really do all of those things [outdoor activities]*" (P4).

Children were mostly interested in the information that was directly available at their wrist, with only a few children using the corresponding app. Children primarily interacted with the app to use features that were not directly available through their wearable such as customizing their wearables' interface and examining their sleep patterns. Three used the app to better schedule and track their exercise (e.g., reviewing the map of distance traveled).

4.2.2 Parents' Interaction with Wearables. Out of 17 families we studied, parents in 12 families stated that they did not actively check their children's data, although 9 of them could view their data from the app that was on their phones. Parents commented that as long as their child is active and healthy, they did not see a need to check their child's data: "*C3 is a pretty active kid. So, I have never had to go in there [the app]. There's no goal for me or my wife like if she has to burn a certain number of calories a day or something like that ... But if she wanted to it's there for her information*" (P3.2). Similarly, P17 claimed that "*health wise, . . . [C17] is very healthy. He eats well. He's doing really well. I mean, he doesn't have any kind of health concerns. So, I don't need to track anything.*" In addition, many parents explained that they would often ask their child for this information directly, such as P2: "*usually we walk home so then I'd be like, how many steps did you do today?*" Other parents mentioned that their child would share the step data even without asking: "*They tell me about it more than I would even look. It's not like I need to check it because they're always telling me about it anyway*" (P12).

The majority of parents evaluated if their child was being active enough on a daily basis, regardless of whether they actively examined how much their child was walking in the app or on the wearable. While making this evaluation, parents typically did not rely on the default 10,000 steps or other numbers set forth by manufacturers and World Health Organization [64]. Parents typically defined being active or not based on the activity level during a day that represented their family's most common routine: "*we just kind of remind him he just needs to do his regular kid activity that he normally does*" (P17). Parents mostly referenced what their child normally does based on their child's school day activity level. For example, P2 said: "*. . . he's been a lot less active than he was during school.*" Similarly, P7 discussed how their routine was changed by the pandemic, making it difficult to establish their child's typical activity levels: "*I wish . . . he had had one when he was going to school every day, because I'm betting that it was like 20,000 steps a day when he was in school versus now . . . I mean, even just we walk a bunch just to walk you into school and things like that, and then they're on the playground. So, I wish I had more of a baseline to understand what COVID has done to our lives.*"

In addition to referencing how their routines changed during the pandemic, parents' comments also indicated that they structured their physical activities around daily events such as school activities and time on the playground. Being able to monitor the amount of activity done in a day was helpful for parents to decide if their child was active enough for the day: "*At school, I knew he was active because he would play during lunch, they would play soccer*" (P14). If parents realized their children are not being active enough, they would encourage their children to be more active, such as asking children to go for a walk: "*we just ask herself how many steps you do today. What? Just 4,000 are you kidding me? You should go out for a walk, come with us to the supermarket to buy some food or just do some steps*" (P10).

4.2.3 Family Engagement over Wearables. Although parents preferred limited interaction with the data reported via wearables, they were more enthusiastic about family interactions that were structured around wearable use. These interactions often brought together wearables worn by other family members, not only a child's wearable. For all families except one, one or both of the parents have a wearable for activity tracking as well, and all older siblings of child participants either had a wearable or had used one.

The ownership of wearables by multiple members in the family added another layer to family interaction around exercise: "*We are going to go out and do something then it is like, 'oh, bring this [the wearable] along' because it adds something to our experience*" (P2). Another parent (P13) explained that her son specifically liked to have his wearable when they go hiking. This activity-oriented use was common in families, as parents thought wearables made exercising as a family more appealing to children. P7 described, "*That's kind of boring compared to going outside and doing recess and going on the playground. It's just, it's not as appealing. So, we are trying to make it [exercising] a little more appealing.*"

Family interaction around wearables was not limited to times when family exercises together. Wearables also motivated family members to be more active throughout the day. Some family members competed with each other: "*We do competitions with each other and we start just trying to keep each other motivated*" (P17). Others preferred family data comparisons: "*At the end of the day, we all look at our own [wearable] and we see who has the largest number*" (C1.1, 7 y.o.). Participants felt both competition and comparison made wearable use more enjoyable. C12.2 (9 y.o.) said: "*it's really fun to compare steps with this one*" referring to his younger sister. A parent even started to wear her wearable more often because her children started using wearables: "*I figured since they were going to be tracking their steps that I might as well see how many more* *steps they had than I had*" (P12). Another parent explained sending emojis to motivate her child: "*I would send him an alert and then I guess when he gets it. Sometimes he will send me something back. But my main goal is just to let him know, I'm moving, so let's move*" (P14).

Although family members generally enjoyed comparing data and competing, parents were concerned that competition could lead to tension. One parent explicitly mentioned not liking the competition between siblings that the wearable incited: "*I don't so much mind competition in general and I like it a lot when they set goals for themselves and try to compete. When they compete with each other, it's just tricky*" (P7). Another one explained the child's competitiveness became annoying from time to time: "*. . . at the point of comparing steps, and I'm like 'Okay, really, are you going to ask me how many steps I have again?'*" (P12).

Some parents complained about not having an easy method for interacting with data from wearables across family members. Only four families reported the use of the leaderboards available through wearables. This occurred partly because family members often did not use the same brand of wearables: "*I had a Fitbit for a while, and . . . [C1.2] and I were on the same leaderboard, so we would interact sometimes. . . now we are all on different platforms, so now we cannot*" (P1). Consequently, family members could not check each other's step counts during the day and mostly compared steps through verbal interaction by the end of the day. P9 commented on the lack of effective interaction with family members (and friends) over wearables: "*something I feel like would be fun, is the connect ability maybe with friends and family. A way to have everybody compete to an online forum.*"

In addition to interaction via wearables for family challenges and comparisons, families shared stories about their conversations over the tracked data. Parents felt these conversations were important to raise awareness of physical activity and eventually on health. Children sometimes initiated the conversation to share a physical activity-related experience with their parents: "*she ended up sleeping over at my niece's house and then they called me like 'guess how much we did, guess how much,' so I feel like it encourages that behavior, it encourages awareness of activity and that's what I think is the biggest*" (P9). Parents would often initiate conversations to aim to raise health awareness by discussing data and reflecting on data to plan other days: "*Her and I will go over them, and I am like, 'Oh, this day your steps were really low but it was because it was raining and we couldn't go outside, now that it is nice outside let's go and try and increase those steps.' I like to look at the sleep data and be like, 'Oh, what happened there? Maybe tomorrow night you can sleep in my bed, maybe we'll try like, a nice hot shower before bed to see if that helps you sleep a little bit better'*" (P8).

Through family competitions, data comparisons, and conversations, parents aimed to instill being healthy as a family value to their children: "*it definitely helped us be more aware of everyone's activeness. It [wearable] kind of makes our health feel like a whole family thing, because we all have the watches now so it's like a family goal, to be healthier and more active*" (P15). Thus, families co-use of wearables were aligned with parents' motivation to raise health awareness.

5 DISCUSSION

Both our child and parent participants commented on the positive impact of commercial wearables on physical activity and health awareness. However, our findings also highlight differences between children's and their parents' perspectives on wearables. These differences open up opportunities for design improvements that can address parents' and children's unique needs and expectations, especially towards increasing children's health awareness. These opportunities are related to the co-use of wearables to support children in goal-setting and situated reflection during naturally-occurring parent-child engagements.

5.1 Goal-Setting Strategies for Sustained Physical Activity and Health Awareness

Our data show children and their parents tend not to care about the exact tracked numbers and their "*quantified past*" [18]. Instead, children primarily focus on what happens at the moment, while parents care about their child's future.

Children's comments supported previous studies [1, 43, 51] and indicated that commercially-available wearables' methods of reporting data and relating this data to health do not fully support children. This is especially an obstacle for younger children, who often cannot make sense of step counts of four- or five-digit numbers. As children do not have a conceptual understanding of what larger numbers mean and consequently what they mean for health, they cannot always define a reasonable goal for themselves and structure their engagement with tracked metrics around other motivations. Some set their goal as getting higher numbers either from their previous steps or comparing with their family and friends. Others use a default daily step goal of 10,000 or rely on step count goals that their parents set for them. This turns children's experience with wearables further into a competitive game. This use practice overlaps with children's desire to have fun with wearables. Children's engagement with wearables is not limited to competing with others. They also compete with themselves, as they perceive daily tracking as a game. However, participant's experiences also indicate a missed opportunity, as this naturally-occurring gamification tended not to be utilized in designs as a learning opportunity.

Although tracking with wearables can motivate children to be physically active, turning tracking into a competitive game can lead children to misinterpret broader concepts around health and wellbeing, instead focusing them on reaching higher step goals or meeting the random step goals set by the devices. From this perspective, the design of the wearables often does not articulate an appropriate activity goal or indicate what means to be active and healthy to children. Even adults may not fully understand their daily step goals and their meaning [15, 44], however, their practices are not structured around reaching a higher number of steps [20]. Such an understanding of physical activity might have a negative impact on children, as behavior development and misunderstanding during middle childhood can turn into an unhealthy habit with lifelong impact.

Children's approach of achieving higher step counts can be questioned from the perspective of sustainability as well. Unlike achieving higher and higher scores in games, reaching higher step counts every day is unrealistic and perhaps unhealthy. However, without the proper understanding of the numbers, where the numbers come from, and what is an appropriate amount of exercise and the risk of overexercising, children often take the daily steps counts as daily challenges, as they often do in a game environment. In addition, the default goals of 10,000 steps on children's trackers are adopted from the adult's version of wearables without considering whether it applies to the children [62]. Thus, it is important for children to develop an understanding of daily step goals that are appropriate to them, knowing they may not be able to achieve higher steps every day, and become less reliant on numbers.

Children's focus on getting more steps, reaching goals, and being instantly gratified about how active they were, are not fully aligned with parents' motivation for having them use the wearables. In introducing wearables into family life, parents have long-term health goals that they expect their children to develop. Parents' focus on the future is reflected in how they interpret being active in their daily lives. Instead of focusing on the exact physical activity counts, parents in our study used other standards to evaluate whether their children are active enough. For instance, for some parents, having a regular school day translated to having enough activity. For others, more outside time, instead of staying inside with screen time, are an expectation of being active. Parents' focus on these activity standards explains their disengagement with the apps and the tracked data. They are more concerned about raising health awareness with their children and desire incorporating routine physical activities in their lives. However, they expect the wearable to take an active role in developing such consciousness, without constant parental mediation.

The use of regular school days as a standard for how active their children also reflects parents' balanced view towards activities. To parents, being active does not mean to reach a certain goal, but to be about as active as on a "*typical*" day. If they believe their child is less active compared to a typical day, they suggest the child to move more or they engage in physical activities with them. Parents want their children to be active, but not overactive. Parents in our study also expressed concerns that their children were becoming obsessed with data, practicing active mediation such as warning their child to rest, and even utilizing restrictive mediation and abandoning the use of wearable. These parental concerns and mediation practices show that parents take a broader understanding of physical activity with it's possible positive and negative effects. However, children's motivations for getting higher step conflicts with parent's aims for balanced use, as gaining more physical activity counts every single day is not sustainable in the long run and may also discourage children from further engaging in physical activities when their goals are not achieved.

Participant experiences in our study indicate missed opportunities for fostering learning moments between parents and children via active mediation and joint media engagement. Garcia et al. [21] and Kim and Bacos [31] previously explored learning opportunities with wearables as experiences built around play and games. Specific to use of activity trackers, Saksono et. al. [53] reported on the "*discovery or educational moments*" enabled with a technology probe designed to promote physical activity. Our findings support the findings from previous studies [21, 31, 33, 34] and illustrated that such educational moments are also useful, and somewhat supported by commercial wearables. Consolvo et al. [15] and Munson and Consolvo [44] suggested alternative goal-setting designs for adults such as multiple goals or changing timeframes. In the case of child-owned wearable use, our findings indicate that parental mediation can support children's goal setting. Parents can teach their children about developing a balanced approach to physical activity and better help children aim long-term health-oriented goals. For this purpose, the initial wearable set-up process can be designed as a joint media engagement activity between parents and children to discuss and define goals. With parent's active mediation, children can revisit the goals occasionally to make necessary updates. It is also important to provide different measurement options (in addition to numbers) to track their activity levels. Child-friendly visualization methods, such as Spaceship Launch [57], can be utilized to address children's conceptual understanding levels depending on age. Making such goal-setting updates is also related to fostering reflection on children's data, which we further discuss in the next section.

5.2 Rethinking Wearable Co-Use for Data Reflection in the Family Setting

Our findings highlight differences in the co-use of child-owned wearables from other technologies that are introduced to family life. Child-owned wearables exemplify a technology that is designed for personal use but end up being an "*inherently shared*" [22] in family life. However, their co-use practices differ from other "*inherently shared*" technologies such as televisions [42] or video-games [28]. The main functions of the wearables are available to a single party, children. Parents can choose to become co-users by interacting with the data reported via apps or using these technologies to facilitate family interaction and child's learning about health.

Distinct from parental mediation practices reported with other technologies and media [e.g. 28, 42], our findings show that majority of the parents do not see a need to mediate their child's interaction with wearables specific for activity tracking. Although the wearables we studied have digital co-use options for parents, e.g. associated apps for accessing data and leaderboards for comparing numbers, these options were less appreciated by parents. Furthermore, parents do not use the app often and do not actively monitor their child's data or seek to identify trends in it.

Although parents do not check their child's data actively, they still stay involved in managing their child's activity levels, engaging co-use practices beyond digital space. We observed various co-use practices (e.g. exercising together as a family, competing) in the families we interviewed. These co-use activities, although centered on wearables and tracked data, typically happened in-person. This type of interaction is different from other joint media engagements in which the interaction takes place in front of the technology, as it is for co-playing video games [28]. Instead, wearables enable conversations on health beyond the duration of their active or co-use. Prior studies have similarly reported family's preferences towards in-person interaction around health [26]. Parents can turn conversations generated via wearables into opportunities for "*educational moments*" [53] and aim to raise health awareness [55] through the learning opportunities initiated via wearables.

A deeper look into families' co-use practices reveals that their co-use activities are mostly limited to collecting and reporting data, but not on reflecting around data. While parents value the educational aspect of technologies [23, 50, 53], in the case of wearables with activity tracking, parents do not utilize these opportunities sufficiently, as data reflection is where they can educate children about health awareness, healthy habits, and the meaning of numbers. This finding is in line with Saksono et al.'s [55] arguments that parents utilized wearables less for raising health awareness, and rarely engage in data reflection with their children.

Similar to Grimes et al.'s [26] finding on the value of family gatherings that are structured around food, the parent-child engagements mediated via wearables can further promote collective data reflection. Our findings also indicate that data reflection can be better integrated into the lived experience with wearables. This is especially important as wearables can be instrumental for situated reflection [21] and embodied learning [10]. Technology could support parents and children in sharing more stories about how they collaboratively interacted with data during family exercises, at the end of the day/week while competing and comparing steps, and random times when parents or children start conversations on activity or how they feel about their health. Our work suggests that beyond encouraging family reflection in the digital space, e.g. engaging parents and children through child-friendly stories in an app [53, 56], it is equally important to support co-use during the naturally-occurring parent-child engagements and make co-use part of the people's lived experiences. This can further enable participatory learning for children and parents. While children are developing health consciousness, parents can further learn about their child's activity behaviors.

A way to enhance child-parent co-use over situated reflection and embodied learning can be the integration of child-friendly visual probes to moments of child-parent interaction. Taking Pina et al.'s [50] technology probe for tracking sleep data in families as an example, these visual probes can ask children and parents to comment on their emotional and physical feelings during exercising as a family or at the end of the day. This will provide insights into children's wellbeing and could create opportunities for parent-child conversation around the impact of physical activity on health. These probes can be integrated into wristbands rather than apps to better support device use in everyday life. These visual probes, daily activities, and daily goals can even be integrated visually to help children and parents better analyze the relationships between these metrics and to reflect on experiences. These design implications can positively impact the efficacy of child-owned wearables by increasing child's health awareness.

6 LIMITATIONS AND FUTURE WORK

We collected data from families with children who already owned wearables. We therefore only studied families where a child was actively using wearables, meaning that our findings might not extend to families or children whose challenges with the devices led them to abandon them, nor families who successfully reached their goals for using the wearables and stopped using them.

Our work does not cover participant's motivations and wearable use practices beyond the 17 families using 12 different wearable models. Our findings may not represent other wearables on the market or other families in general. We purposefully aimed to understand the motivations and experiences of families who introduced children-owned wearables into their lives naturally. As a result, our sample represents a population who can afford to purchase wearables for their child and decide to do so. Motivations for adoption or use of the device may differ for particularly high and low socioeconomic families. Thus, our design recommendations may be limited to use of these technologies in certain socioeconomic status (SES) groups. Future studies with larger sample sizes that compare families' use of wearables across different SES levels might bring further insights on the integration of children-owned wearables in family lives. Moreover, while other studies [e.g. 29] reported data security, privacy, and surveillance concerns, these concerns were not common in our data, mentioned only by two parents and one child. Future studies are needed to further uncover the factors impacting perceptual differences.

Previous studies have examined children's use of wearables for certain chronic health conditions [12, 30, 32, 61]. Our participants were self-reported as typically healthy. Thus, some perspectives and practices around child-owned wearables may not extend to circumstances where co-use is required for collaborative management of a chronic condition. Moreover, children of different ages may have different motivations towards wearable use. These motivations, as well as their age-related abilities and skills, can have an impact on use practice. Some aspects of our findings may not generalize beyond the studied age group.

Data collection took place in June and July of 2020, when most daily activities, regular schedules, and therefore activity levels were interrupted because of the COVID-19 pandemic. Two parents described purchasing wearable to their child for the first time during the pandemic because of their more sedentary lifestyle. Although other families introduced wearables before the pandemic, their use during the time of the interview might be influenced by concerns that their child is not getting enough activity. We tried to address this limitation by asking participants to compare their use throughout their wearable ownership, but we acknowledge that the pandemic may have impacted their perspectives on the wearable.

As we aimed to explore family's natural use of child-owned wearables, we preferred an inductive approach rooted in their lived experiences. While our findings indicate informal learning opportunities around health-related topics, future studies could extend our understanding of the success of these opportunities by considering how they are and are not supported by educational theories.

7 CONCLUSION

We explored individual and collaborative use of child-owned wearables in families who naturally adopted these technologies. Our interviews with 17 families identified opportunities for better implementation of these technologies in family life for health awareness. Families can better structure their co-use practices around goal-setting strategies and data reflection to further turn wearable use into an educational experience for children towards health. Future work testing different goal-setting strategies and parent-child engagement for data reflection can expand our understanding on the impact of these factors on lived experiences with child-owned wearable. Conducting longitudinal studies with families who naturally adopted child-owned wearables can bring further insights on the use of wearables for raising health awareness.

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REFERENCES

[1] Swamy Ananthanarayan, Katie Siek, and Michael Eisenberg. 2016. A craft approach to health awareness in children. In *Proceedings of the 2016 ACM Conference on Designing Interactive Systems* (DIS '16), Association for Computing Machinery, New York, NY, USA, 724–735. https://doi.org/10.1145/2901790.2901888

[2] Päivi Astedt-Kurki, Hanna Hopia, and Anne Vuori. 1999. Family health in everyday life: a qualitative study on well-being in families with children. *J Adv Nurs* 29, 3 (March 1999), 704–711.

[3] Päivi Astedt-Kurki, Eija Paavilainen, and Kristiina Lehti. 2001. Methodological issues in interviewing families in family nursing research. *J Adv Nurs* 35, 2 (July 2001), 288–293. https://doi.org/10.1046/j.1365-2648.2001.01845.x

[4] Brigid Barron. 2004. Learning ecologies for technological fluency: gender and experience differences. *Journal of Educational Computing Research* 31, 1 (2004), 1–36. https://doi.org/10.2190/1N20-VV12-4RB5-33VA

[5] Brigid Barron. 2006. Interest and self-sustained learning as catalysts of development: a learning ecology perspective. *Human Development* 49, 4 (2006), 193–224. https://doi.org/10.1159/000094368

[6] Brigid Barron, Caitlin Kennedy Martin, Lori Takeuchi, and Rachel Fithian. 2009. Parents as learning partners in the development of technological fluency. *International Journal of Learning and Media* 1, 2 (2009), 55–77. https://doi.org/10.1162/ijlm.2009.0021

[7] Barbara L. Beacham and Janet A. Deatrick. 2015. Children with chronic conditions: perspectives on condition management. *Journal of Pediatric Nursing* 30, 1 (February 2015), 25–35. https://doi.org/10.1016/j.pedn.2014.10.011

[8] Lindsay Blackwell, Emma Gardiner, and Sarita Schoenebeck. 2016. Managing expectations: technology tensions among parents and teens. In *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing - CSCW '16*, ACM Press, San Francisco, CA, USA, 1388–1399. https://doi.org/10.1145/2818048.2819928

[9] Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology* 3, 2 (January 2006), 77–101. https://doi.org/10.1191/1478088706qp063oa

[10] Ilona Buchem. 2019. Design principles for wearable enhanced embodied learning of movement. In *Learning and Collaboration Technologies. Ubiquitous and Virtual Environments for Learning and Collaboration* (Lecture Notes in Computer Science), Springer, Cham, 13–25. https://doi.org/10.1007/978-3-030-21817-1_2

[11] Meng-Ying Chan, Yi-Hsuan Lin, Long-Fei Lin, Ting-Wei Lin, Wei-Che Hsu, Chia-yu Chang, Rui Liu, Ko-Yu Chang, Min-hua Lin, and Jane Yung-jen Hsu. 2017. WAKEY: assisting parent-child communication for better morning routines. In *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing* (CSCW '17), Association for Computing Machinery, New York, NY, USA, 2287–2299. https://doi.org/10.1145/2998181.2998233

[12] Franceli L. Cibrian, Kimberley D. Lakes, Arya Tavakoulnia, Kayla Guzman, Sabrina Schuck, and Gillian R. Hayes. 2020. Supporting self-regulation of children with ADHD using wearables: tensions and design challenges. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (CHI '20), Association for Computing Machinery, New York, NY, USA, 1–13. https://doi.org/10.1145/3313831.3376837

[13] Lynn Schofield Clark. 2011. Parental mediation theory for the digital age. *Communication Theory* 21, 4 (2011), 323–343. https://doi.org/10.1111/j.1468-2885.2011.01391.x

[14] Cynthia Garcia Coll and Laura A. Szalacha. 2004. The multiple contexts of middle childhood. *Future of Children* 14, 2 (2004), 81–97.

[15] Sunny Consolvo, Predrag Klasnja, David W. McDonald, and James A. Landay. 2009. Goal-setting considerations for persuasive technologies that encourage physical activity. In *Proceedings of the 4th International Conference on Persuasive Technology* (Persuasive '09), Association for Computing Machinery, New York, NY, USA, 1–8. https://doi.org/10.1145/1541948.1541960

[16] Dataintelo. 2019. Global kids smartwatch market research report 2019-2025. Retrieved September 14, 2020 from https://dataintelo.com/report/global-kids-smartwatch-market/

[17] Katie Davis, Anja Dinhopl, and Alexis Hiniker. 2019. "Everything's the phone": understanding the phone's supercharged role in parent-teen relationships. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems - CHI '19*, ACM Press, Glasgow, Scotland Uk, 1–14. https://doi.org/10.1145/3290605.3300457

[18] Chris Elsden, David S. Kirk, and Abigail C. Durrant. 2016. A quantified past: toward design for remembering with personal informatics. *Human–Computer Interaction* 31, 6 (November 2016), 518–557. https://doi.org/10.1080/07370024.2015.1093422

[19] Daniel A. Epstein, Clara Caldeira, Mayara Costa Figueiredo, Xi Lu, Lucas M. Silva, Lucretia Williams, Jong Ho Lee, Qingyang Li, Simran Ahuja, Qiuer Chen, Payam Dowlatyari, Craig Hilby, Sazeda Sultana, Elizabeth V. Eikey, and Yunan Chen. 2020. Mapping and taking stock of the personal informatics literature. *Proc. ACM Interact. Mob. Wearable Ubiquitous Technol.* 4, 4 (December 2020), 126:1-126:38. https://doi.org/10.1145/3432231

[20] Daniel A. Epstein, An Ping, James Fogarty, and Sean A. Munson. 2015. A lived informatics model of personal informatics. In *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing* (UbiComp '15), Association for Computing Machinery, New York, NY, USA, 731–742. https://doi.org/10.1145/2750858.2804250

[21] Brittany Garcia, Sharon Lynn Chu, Beth Nam, and Colin Banigan. 2018. Wearables for learning: examining the smartwatch as a tool for situated science reflection. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, ACM, Montreal QC Canada, 1–13. https://doi.org/10.1145/3173574.3173830

[22] Radhika Garg and Christopher Moreno. 2019. Understanding motivators, constraints, and practices of sharing internet of things. *Proc. ACM Interact. Mob. Wearable Ubiquitous Technol.* 3, 2 (June 2019), 44:1-44:21. https://doi.org/10.1145/3328915

[23] Elisabeth Gee, Lori Takeuchi, and Ellen Wartella (Eds.). 2017. *Children and families in the digital age: learning together in a media saturated culture* (1st ed.). Routledge, New York.

[24] Arup Kumar Ghosh, Karla Badillo-Urquiola, Shion Guha, Joseph J. LaViola Jr, and Pamela J. Wisniewski. 2018. Safety vs. surveillance: what children have to say about mobile apps for parental control. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems - CHI '18*, ACM Press, Montreal QC, Canada, 1–14. https://doi.org/10.1145/3173574.3173698

[25] Sandra Burri Gram-Hansen. 2019. Family wearables – what makes them persuasive? *Behaviour & Information Technology* (November 2019), 1–13. https://doi.org/10.1080/0144929X.2019.1694993

[26] Andrea Grimes, Desney Tan, and Dan Morris. 2009. Toward technologies that support family reflections on health. In *Proceedings of the ACM 2009 international conference on Supporting group work* (GROUP '09), Association for Computing Machinery, New York, NY, USA, 311–320. https://doi.org/10.1145/1531674.1531721

[27] Alexis Hiniker, Sarita Y. Schoenebeck, and Julie A. Kientz. 2016. Not at the dinner table: parents' and children's perspectives on family technology rules. In *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing* (CSCW '16), Association for Computing Machinery, New York, NY, USA, 1376–1389. https://doi.org/10.1145/2818048.2819940

[28] Hee Jhee Jiow, Sun Sun Lim, and Julian Lin. 2017. Level up! Refreshing parental mediation theory for our digital media landscape. *Communication Theory* 27, 3 (2017), 309–328. https://doi.org/10.1111/comt.12109

[29] Mikkel S. Jørgensen, Frederik K. Nissen, Jeni Paay, Jesper Kjeldskov, and Mikael B. Skov. 2016. Monitoring children's physical activity and sleep: a study of surveillance and information disclosure. In *Proceedings of the 28th Australian Conference on Computer-Human Interaction* (OzCHI '16), Association for Computing Machinery, New York, NY, USA, 50–58. https://doi.org/10.1145/3010915.3010936

[30] Elizabeth Kaziunas, Mark S. Ackerman, Silvia Lindtner, and Joyce M. Lee. 2017. Caring through data: attending to the social and emotional experiences of health datafication. In *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing* (CSCW '17), Association for Computing Machinery, New York, NY, USA, 2260–2272. https://doi.org/10.1145/2998181.2998303

[31] Si Jung Kim and Catherine A. Bacos. 2020. Wearable stories for children: embodied learning through pretend and physical play. *Interactive Learning Environments* (May 2020), 1–13. https://doi.org/10.1080/10494820.2020.1764979

[32] Yiannis Koumpouros and Thomas Toulias. 2020. User centered design and assessment of a wearable application for children with autistic spectrum disorder supporting daily activities. In *Proceedings of the 13th ACM International Conference on PErvasive Technologies Related to Assistive Environments*, ACM, Corfu Greece, 1–9. https://doi.org/10.1145/3389189.3398002

[33] Victor R. Lee, Joel R. Drake, and Jeffrey L. Thayne. 2016. Appropriating quantified self technologies to support elementary statistical teaching and learning. *IEEE Transactions on Learning Technologies* 9, 4 (October 2016), 354–365. https://doi.org/10.1109/TLT.2016.2597142

[34] Victor R. Lee and R. Benjamin Shapiro. 2019. A broad view of wearables as learning technologies: current and emerging applications. In *Learning in a Digital World: Perspective on Interactive Technologies for Formal and Informal Education*, Paloma Díaz, Andri Ioannou, Kaushal Kumar Bhagat and J. Michael Spector (eds.). Springer, Singapore, 113–133. https://doi.org/10.1007/978-981-13-8265-9_6

[35] Ian Li, Anind Dey, and Jodi Forlizzi. 2010. A stage-based model of personal informatics systems. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '10), Association for Computing Machinery, New York, NY, USA, 557–566. https://doi.org/10.1145/1753326.1753409

[36] Qingyang Li, Daniel A. Epstein, Clara Caldeira, and Yunan Chen. 2020. Supporting caring among intergenerational family members through family fitness tracking. In *PervasiveHealth '20*, Atlanta, GA, USA, 1–10. https://doi.org/10.1145/3421937.3422018

[37] Sonia Livingstone. 2002. *Young people and new media: childhood and the changing media environment* (1st ed.). SAGE, London; Thousand Oaks, CA.

[38] Sonia Livingstone and Ellen J. Helsper. 2008. Parental mediation of children's internet use. *Journal of Broadcasting & Electronic Media* 52, 4 (November 2008), 581–599. https://doi.org/10.1080/08838150802437396

[39] Kai Lukoff, Taoxi Li, Yuan Zhuang, and Brian Y. Lim. 2018. TableChat: mobile food journaling to facilitate family support for healthy eating. *Proc. ACM Hum.-Comput. Interact.* 2, CSCW (November 2018), 114:1-114:28. https://doi.org/10.1145/3274383

[40] Kelly A. Mackintosh, Stephanie E. Chappel, Jo Salmon, Anna Timperio, Kylie Ball, Helen Brown, Susie Macfarlane, and Nicola D. Ridgers. 2019. Parental perspectives of a wearable activity tracker for children younger than 13 years: acceptability and usability study. *JMIR mHealth and uHealth* 7, 11 (2019), e13858. https://doi.org/10.2196/13858

[41] Brittany Masteller, John Sirard, and Patty Freedson. 2017. The physical activity tracker testing in youth (P.A.T.T.Y.) study: Content analysis and children's perceptions. *JMIR Mhealth Uhealth* 5, 4 (April 2017). https://doi.org/10.2196/mhealth.6347

[42] Kelly Mendoza. 2013. Surveying Parental mediation: connections, challenges and questions for media literacy. *Journal of Media Literacy Education* 1, 1 (September 2013), 28–41.

[43] Jan Müller, Anna-Maria Hoch, Vanessa Zoller, and Renate Oberhoffer. 2018. Feasibility of physical activity assessment with wearable devices in children aged 4–10 years—a pilot study. *Front Pediatr* 6, (January 2018). https://doi.org/10.3389/fped.2018.00005

[44] Sean A. Munson and Sunny Consolvo. 2012. Exploring goal-setting, rewards, self-monitoring, and sharing to motivate physical activity. In *2012 6th International Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth) and Workshops*, 25–32. https://doi.org/10.4108/icst.pervasivehealth.2012.248691

[45] Amy I. Nathanson. 1999. Identifying and explaining the relationship between parental mediation and children's aggression. *Communication Research* 26, 2 (1999), 124–143. https://doi.org/10.1177/009365099026002002

[46] Jasmin Niess and PawełW. Woźniak. 2018. Supporting meaningful personal fitness: the tracker goal evolution model. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, Association for Computing Machinery, New York, NY, USA, 1–12. https://doi.org/ttps://doi.org/10.1145/3173574.3173745

[47] Işıl Oygür, Daniel A. Epstein, and Yunan Chen. 2020. Raising the responsible child: collaborative work in the use of activity trackers for children. *Proc. ACM Hum.-Comput. Interact* 4, CSCW2 (2020), 157:1-157:23. https://doi.org/10.1145/3415228

[48] Michael Quinn Patton. 1990. *Qualitative evaluation and research methods* (2nd ed.). Sage, Thousand Oaks, CA, US.

[49] Laura R. Pina, Sang-Wha Sien, Teresa Ward, Jason C. Yip, Sean A. Munson, James Fogarty, and Julie A. Kientz. 2017. From personal informatics to family informatics: understanding family practices around health monitoring. In *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing*, ACM, Portland Oregon USA, 2300–2315. https://doi.org/10.1145/2998181.2998362

[50] Laura Pina, Sang-Wha Sien, Clarissa Song, Teresa M. Ward, James Fogarty, Sean A. Munson, and Julie A. Kientz. 2020. DreamCatcher: exploring how parents and school-age children can track and review sleep information together. *Proc. ACM Hum.-Comput. Interact.* 4, CSCW1 (May 2020), 070:1-070:25. https://doi.org/10.1145/3392882

[51] Emma Rich, Sarah Lewis, Andy Miah, Deborah Lupton, and Lukasz Piwek. 2020. *Digital health generation? Young people's use of 'healthy lifestyle' technologies*. University of Bath, Bath, UK. Retrieved from https://www.digitalhealthgeneration.net/final-report

[52] John Rooksby, Mattias Rost, Alistair Morrison, and Matthew Chalmers Chalmers. 2014. Personal tracking as lived informatics. In *Proceedings of the 32nd annual ACM conference on Human factors in computing systems - CHI '14*, ACM Press, Toronto, Ontario, Canada, 1163–1172. https://doi.org/10.1145/2556288.2557039

[53] Herman Saksono, Carmen Castaneda-Sceppa, Jessica Hoffman, Vivien Morris, Magy Seif El-Nasr, and Andrea G. Parker. 2020. Storywell: designing for family fitness app motivation by using social rewards and reflection. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (CHI '20), Association for Computing Machinery, New York, NY, USA, 1–13. https://doi.org/10.1145/3313831.3376686

[54] Herman Saksono, Carmen Castaneda-Sceppa, Jessica Hoffman, Magy Seif El-Nasr, Vivien Morris, and Andrea G. Parker. 2018. Family health promotion in low-SES neighborhoods: a two-month study of wearable activity tracking. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (CHI '18), Association for Computing Machinery, New York, NY, USA, 1–13. https://doi.org/10.1145/3173574.3173883

[55] Herman Saksono, Carmen Castaneda-Sceppa, Jessica Hoffman, Magy Seif El-Nasr, Vivien Morris, and Andrea G. Parker. 2019. Social reflections on fitness tracking data: a study with families in low-SES neighborhoods. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (CHI '19), Association for Computing Machinery, New York, NY, USA, 1–14. https://doi.org/10.1145/3290605.3300543

[56] Herman Saksono and Andrea G. Parker. 2017. Reflective informatics through family storytelling: self-discovering physical activity predictors. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (CHI '17), ACM, New York, NY, USA, 5232–5244. https://doi.org/10.1145/3025453.3025651

[57] Herman Saksono, Ashwini Ranade, Geeta Kamarthi, Carmen Castaneda-Sceppa, Jessica A. Hoffman, Cathy Wirth, and Andrea G. Parker. 2015. Spaceship Launch: designing a collaborative exergame for families. In *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing* (CSCW '15), Association for Computing Machinery, New York, NY, USA, 1776–1787. https://doi.org/10.1145/2675133.2675159

[58] Christopher L. Schaefbauer, Danish U. Khan, Amy Le, Garrett Sczechowski, and Katie A. Siek. 2015. Snack Buddy: supporting healthy snacking in low socioeconomic status families. In *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing* (CSCW '15), Association for Computing Machinery, New York, NY, USA, 1045–1057. https://doi.org/10.1145/2675133.2675180

[59] Sara E. Schaefer, Cynthia Carter Ching, Heather Breen, and J. Bruce German. 2016. Wearing, thinking, and moving: testing the feasibility of fitness tracking with urban youth. *American Journal of Health Education* 47, 1 (January 2016), 8–16. https://doi.org/10.1080/19325037.2015.1111174

[60] L. Takeuchi and R. Stevens. 2011. *The new coviewing: designing for learning through joint media engagement*. New York: The Joan Ganz Cooney Center at Sesame Workshop, New York. Retrieved December 29, 2020 from https://joanganzcooneycenter.org/publication/the-new-coviewing-designing-for-learning-through-joint-media-engagement/

[61] Tammy Toscos, Kay Connelly, and Yvonne Rogers. 2012. Best intentions: health monitoring technology and children. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '12), Association for Computing Machinery, New York, NY, USA, 1431–1440. https://doi.org/10.1145/2207676.2208603

[62] Catrine Tudor-Locke, Cora L. Craig, Michael W. Beets, Sarahjane Belton, Greet M. Cardon, Scott Duncan, Yoshiro Hatano, David R. Lubans, Timothy S. Olds, Anders Raustorp, David A. Rowe, John C. Spence, Shigeho Tanaka, and Steven N. Blair. 2011. How many steps/day are enough? for children and adolescents. *Int J Behav Nutr Phys Act* 8, 1 (July 2011), 78. https://doi.org/10.1186/1479-5868-8-78

[63] Patti M. Valkenburg, Marina Krcmar, Allerd L. Peeters, and Nies M. Marseille. 1999. Developing a scale to assess three styles of television mediation: "instructive mediation," "restrictive mediation," and "social coviewing." *Journal of Broadcasting & Electronic Media* 43, 1 (January 1999), 52–66. https://doi.org/10.1080/08838159909364474

[64] World Health Organization. 2019. *Guidelines on physical activity, sedentary behaviour, and sleep for children under 5 years of age*. Retrieved September 14, 2020 from http://www.ncbi.nlm.nih.gov/books/NBK541170/