

Raising the Responsible Child: Collaborative Work in the Use of Activity Trackers for Children

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Commercial activity trackers are increasingly being designed for children as young as 3 years old. However, we have limited understanding of family use practices around these trackers. To provide an overall view of how families naturally use activity trackers towards collaborative management of family health, we systematically identified 9 trackers designed for children available on 4 consumer electronics retailers. Our data is composed of 2,628 user reviews both from the consumer retailers (for the wearables) and mobile application stores (for the associated apps). Our findings indicate children's and parents' collaborative use of these technologies beyond health and wellness. Parents state that their children enjoy practicing independence and rewards while contributing to family health management and daily life requirements. Parents expect these devices to ease their life and to teach their children to become more responsible for their health, daily tasks, and schedule. However, the current designs give limited agency on child's side and require parents' active participation for wearable-app coordination. For these reasons, they do not fully address parents' expectations in decreasing their workload. On the other hand, they have the potential to facilitate family interaction with challenges structured around the data reported through trackers.

CCS Concepts: • **Human-centered computing** → **Mobile devices**; **User studies**.

Additional Key Words and Phrases: activity tracking; family informatics; personal informatics; children; technology use in family life

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1 INTRODUCTION

As children-oriented commercial activity trackers continue to proliferate as tools for introducing healthy lifestyles beyond the needs of chronic diseases, there is a need to understand how these tools fulfill children's and parent's expectations and how they impact family life. In order to study these issues, previous HCI work introduced new tools, interventions, and probes for children and families and exclusively studied these interventions from the perspective of tracking and managing health and wellbeing [26, 49, 50, 54, 61, 62]. These studies do not focus on the natural use (natural introduction and use of the technology in family life) of these technologies with their possible impact on issues beyond health and wellness.

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Studying natural use of these technologies is important for developing a better understanding of what family-centered tracking entails and for designing activity trackers for children that can better address family-centered needs. To do so, we draw on Pina et al.'s notion of family informatics [58], which points out that health tracking is not always an individual practice and family members serve interrelated roles in managing health. We specifically look into children-oriented activity trackers' mediating role in family life and explore the use of trackers as a new technology in family life, building on the previous knowledge on invisible work [69, 72].

To do so, we qualitatively analyzed 2,628 user reviews from 9 systematically selected activity trackers for children. We uncover the mediating role of this technology on family life beyond family-shared health management. Our findings illustrate the collaborative effort required for children-oriented activity trackers, especially in the case of younger children who do not own a smart device to use the app of the tracker yet. This results in new tasks, as well as the restructuring of the existing invisible work, for parents who want to raise children to be responsible to manage their own health and daily life.

This paper contributes to existing CSCW literature by:

- Empirically describing parent's experiences with children-oriented activity trackers in their daily lives alongside their perspectives on their children's experiences. These experiences contribute to literature describing opportunities and challenges around family informatics.
- Articulating the collaborative work required for the use of children-oriented activity trackers such as monitoring and entering data into the phone app that the device pairs with. These findings contribute to ongoing discussion on technology's influence on the invisible work in parenting.
- Identifying the mediating role of children-oriented activity trackers on family life beyond health and wellness, such as competing as a family, managing daily chores or teaching time management. We extend prior work to highlight that these trackers can facilitate practices in children beyond health management and offer insights for the design of trackers based on their collaborative use practices in families.

2 RELATED WORK

We review the existing work on children-oriented activity trackers and family informatics and situate our research relative to technology use in family life and its impact on the invisible work in parenting.

2.1 The Rise of Family Informatics

Engaging in regular physical activity, sleep routines, moderate to vigorous exercise, and healthy diet early in a life journey increase the chance of having a physically and mentally healthy life [78]. Over the years, we have witnessed the search for strategies to bring motivation and positive behavior change on physical activity of children [73, 77]. Lately, activity trackers have been introduced with the same goals. While we do not have enough evidence to support the positive impact of these technologies on long-term [10], studies report on their potential to reinforce self-care, health and wellness for adults [14, 16]. This understanding and the concerns on the increasing sedentary life style of children [78] motivated manufacturers to introduce activity trackers specifically designed for children.

Most commercially-available trackers designed for children are composed of a wearable device (typically a wristband) and an app operated through a smart device (most often a phone). Most trackers claim to be designed for children as young as 3 years old. They use color, child-friendly graphics, and smaller wristbands to better address the needs of children. Some include built-in

games and reward systems to motivate children to be more active [2, 25]. The games are similar to exergames, requiring the user to reach certain activity level in order to unlock a new step on the device. Rewards are either in the form of stars and badges that the child can receive through reaching daily and weekly goals or digital coins and/or physical rewards (set by parents) that are rewarded for completing tasks.

Scholars previously studied activity tracking among children in relation to monitoring health-metrics [2], usage [61, 66], usability [49], behavior change [50], persuasiveness [25], surveillance [24, 41], feasibility [54], school activities [19, 47], social aspects [52, 75], and gamification [1, 67]. The results from these studies report both positive and negative experiences about the use of activity trackers by children. For example, Müller et al. [54] and Ananthanarayan et al. [2] reported younger children's inability to make sense of the health-metrics reported through trackers and the possible positive impact of physical activity on their health and wellness. Children tend to keep using the tracker when friends own a similar device [50]. Social rewards designed around parent-child interaction can influence child's internalization of extrinsic motivation to use trackers [60].

The majority of the commercially-available activity trackers for children are developed based on adult versions of trackers [25]. However, children-oriented activity trackers tend to be used differently from adults. Younger children do not own smartphones. Even they own a smart device, the Children's Online Privacy Protection prevents manufacturers addressing apps for children under 13 directly. As a result, parents become the "gatekeepers" of their child-oriented activity tracker's app [49] and the activity tracking practice become a family engagement. This situation renders a complex family relationship that has been studied under family informatics.

Family informatics examines self-monitoring, self-management and self-tracking of health data in the collaborative efforts of health tracking as a family [58]. Prior HCI and CSCW work has examined how families with a child that has a chronic condition collaboratively monitor health data, such as Juvenile Idiopathic Arthritis [58], type 1 diabetes [42, 74], and asthma [40, 80]. However, studies also show that families without children with chronic health conditions also use technology to collaboratively track and manage their health [25, 43, 57, 61, 62].

In family-centered health informatics, parents are typically assumed as caregivers for their children [57], which can assign children a passive role in family health management and put the burden of tracking and sensemaking on the parent. In order to examine how technology can impact parent-child collaboration towards family health, researchers have developed probes such as Spaceship Launch [63], DreamCatcher [57], TableChat [48], and Snack Buddy [65]. These probes use children-friendly visualizations and data sharing among family members to increase family engagement [11] and "parental modeling" of positive behaviors to children [26]. They serve as tools to initiate conversations and reflections around healthy living practices (e.g. activity, diet), promote healthy lifestyle through competitions, and increase interaction and bonding opportunities [26, 60]. However, parents are often do not wish to share their own health data with their children [26, 57] and worry about the burden of having to routinely use the technology [60].

Our study extends the knowledge from these studies in two respects. First, prior studies have typically designed and deployed interventions with families, distributing technology probes and requiring participants to use them for a limited amount of time. By studying the experiences of people who integrated child-oriented activity trackers into their lives, we can deepen our knowledge on how family-centered tracking is practiced in natural settings. Second, previous studies and systems tend to examine family experiences exclusively focusing on health and wellness. Through the analysis of the use of these technologies, we uncovered the importance of tracking practices beyond health and wellness to families, such as chore management.

2.2 Technology Use in Family Life

Over the years we witnessed how technologies such as televisions, smartphones, computers, video games, and media have played role in family interaction, coordination, entertainment and connection [39]. Studies that explored the users' experiences with use [30] and non-use [64] of these technologies revealed conflicting results regarding the impact of technology on individuals and families and regarding their overall value [37]. Technologies can help parents balance their work, home and personal life more efficiently [3]. At the same time, they create distraction during family time and might bring major negative impact on children-parent relationship [31, 70]. Similarly, the moderate media use can positively impact children's connectivity, social life and academic success and heavy use can result in depression and social withdrawal for children [59].

Child-technology interaction leads to various concerns among parents [55]. Previous studies documented parents' concerns for their children's online safety [23, 33], screen time [27, 46], sedentary lifestyle [41] and technology attachment [38]. In order to address their worries on the use of technology by their children, some parents develop technology use and nonuse practices with and around their children [21]. Others monitor their children or introduce rules of duration and context of use for technology [51]. These rules have the possibility to create additional concern for parents as they can cause tension and conflict between the parents and children [5]. Research has suggested that parents neither to fully restrict nor fully permit technology use, instead aim to strike a "healthy balance" [30]. All these render a different experience with technology than the once introduced as a mean for managing life easier [3, 4].

Technology often gets introduced into houses and family life with the promise to decrease the individual's workload [4]. This promise has become more important over the years as the understanding on invisible work developed. Invisible work is the work that requires effort and creates burden, but is not visible to others [69, 71, 72]. It is mostly taken for granted by the people who it is invisible. While it is possible to design technologies that do not increase invisible work [6, 69], current designs introduced in family life are not always successful in term of reducing the time and attention demand from parents [3]. As it is the case for other CSCW systems [69, 72], contemporary technologies which promise to support parents in decreasing invisible work instead make the invisible work visible or only restructure it [3].

Invisible work in parenting has lately become a bigger concern because of the increasing work-home struggles, mental load and "intensive parenting" practices [28, 32, 55]. People want to be good employees. In contemporary work context, this requires additional time commitment beyond working hours especially with the increased connectivity through Internet and smartphones [3]. While they require to work more at home and during weekends, people also want to be good parents who are able to address their child's problems, take good care of them and support the child's cognitive and emotional development [28, 55]. Accomplishing this work-home balance and at the same time taking care of the self is a stress factor for parents [3, 28]. Consequently, contemporary parents are looking for technologies to support their work-life balance and to help them to be the ideal parent in order to raise the ideal child that is responsible, disciplined and independent [3, 55].

Different from many other technologies that concern parents, children's activity trackers are introduced with the promise to bring a "healthier lifestyle" as a family [15] and are often perceived positively by parents. However, previous studies looking into parents' and children's perception and use of these technologies often report conflicting results regarding their use. Gram-Hansen [25] observed the ability of child-oriented activity trackers to increase child-parent dialogue through the communication over tracked data and competing over daily steps. On the other hand, Jørgensen et al. [41] described worries by some parents when seeing their child's insufficient activity or sleep

through the data reported by trackers. These worries resulted in introduction of new parental rules to encourage more physical activity or sleep routines. There are also debates about the possible negative effect of these reward-based technologies on the long term as they can demotivate children who cannot reach daily goals or cause obsessive behaviors and thoughts [45]. Thus, it is necessary to conduct more research on the use of this new technology in family life.

While contributing the literature on technology use in family life, we also explore a technology with more varied use by all family members than other technologies. Most of the existing studies on technology use in families report results from experiences with a technology that has a single point of interaction (e.g., tablet, smartphone). As the case for television [27], mobile device [31], or social media [79], these technologies are either individually used or shared among family members [20, 29]. However, activity trackers are composed of two points of interaction, a wearable device and an app. This renders a different dynamic for the use of a technology by a family.

3 METHOD

In this study, we aimed to provide a snapshot of the natural use of a list of popular activity trackers for children by analyzing reviews left on app stores and product pages. While we understand the value of conducting in-depth user studies and intervention-based studies, these studies tend to be small scale oriented and do not offer a broad overview of a large number of experiences from users who integrated technologies in their daily lives naturally. Previous studies [7, 13, 18, 22] communicate the value of studying the publicly available user reviews for this purpose. User reviews give valuable insights on users' satisfaction [17], problems [56] and perception on usefulness, quality and ease of use of the item reviewed [76]. Users share their wishes and suggest ways of addressing problems as well [56]. Consequently, reviewing feedback from users have the potential to provide design improvements, inform product development [44]. As these strengths overlap with our aim, we followed the methodological approaches of these work and designed a study involving the qualitative analysis of user reviews on activity trackers specifically designed for children. In order to better frame the experience with these technologies, we analyzed both the product and the app reviews of these technologies.

Children-oriented activity trackers exemplify an "inherently shared" technology, similar to how Garg and Moreno describe the domestic use of internet-of-things [20]. This previous study explores how users take turns and/or co-use smart devices available in household context. Distinct from sharing and/or co-use practices reported in Garg and Moreno's study [20], parents and children simultaneously own the smart system explored in our study. In families with younger children, parents are the primary users of the app and the children are the primary users of the wearable component of the children-oriented activity trackers. As the system requires pairing of the app and the wearable, the use of children's activity tracker is inherently collaborative, and individual's use of the technology cannot be separated from each other. Individuals, typically parents, wrote the reviews, so we only have access to parents' perspective of this collaboration. However, parents often shared anecdotes of family use, providing insight into family practices of these technologies. Our examination of user reviews primarily focuses on family's collaborative practices from the perspective of parents, not children.

3.1 Selection of Activity Trackers

We systematically searched retailer websites in order to determine the activity trackers to be included in our study. We used two top 10 retailer lists for consumer electronics [68] and online electronic and media [53] to determine where to identify children's trackers that are on the market. Among the 7 overlapping retailers in these two lists, 5 retailers were selling activity trackers for children. These are 1) Amazon, 2) BestBuy, 3) Walmart, 4) Dell, and 5) Target.

On each retailer website, we conducted a search by combining the product category name as listed on each website (i.e., activity tracker, fitness tracker, or health band) with the keywords “kid” and “child”. We followed strategies from prior literature [7, 13] to select activity trackers based on the popularities using star ratings (≥ 3 stars) and number of available user reviews (≥ 100 reviews). Our initial review on activity trackers for children indicated that reviews of poorly-rated trackers primarily focused on baseline usability problems, such as failing logins or devices that would not charge. By studying the popular and widely adopted trackers, we are able to examine the usage scenarios and social issues experienced and reported by parents in their daily lives beyond usability or technology breakdowns.

We reviewed all the products that showed up after popularity filter and omitted the ones that are not specifically designed for children. In other words, we excluded the products that explicitly list adults in addition to children, as their target user. Our initial list included 10 products; however, the detailed analysis of each product indicated two of the products (BingoFit Young and YoYoFit Slim Kids) which were different brandings of the same product. Therefore, we evaluated these as a single product and labeled them as BingoFit Young in this paper. Table 1 includes our final list of 9 products representing 7 brands: 1) Advista Sports (AS), 2) BingoFit Young (BFY), 3) Fitbit Ace (FA), 4) Fitbit Ace 2 (FA2), 5) Garmin Vivofit Jr. (GVJ), 6) Garmin Vivofit Jr. 2 (GVJ2), 7) Joy Octopus Watch v2 (JO2), 8) LeapFrog LeapBand (LB), and 9) Trendy Pro (TP).

3.2 Data and Data Analysis

We downloaded all available reviews from the 5 retail websites in late September-Early October 2019. Furthermore, to render a holistic picture of user’s experience, we also downloaded the associated app reviews of the selected tracking devices from App Store and Google Play, whenever applicable. One of the trackers (LB) has a computer software rather than an app, and the trackers from same brand (Fitbit and Garmin) share a common app. As a result, Table 2 lists a total 6 apps for the 9 trackers reviewed in the study: 1) Ufit (UT), 2) CC Band (CC), 3) Fitbit (FB), 4) Vivofit Jr (VJ), 5) Octopus Watch by Joy (OW), and 6) VeryFit 2.0 (VF).

While it was possible to scrape all the user reviews available on Google Play (except for Fitbit for which we were only able to download 100,000 reviews), permissions and rate limits only allowed us to scrape the 500 latest reviews from the Apple App Store. We therefore analyzed fewer reviews from the App Store than Google Play. In addition, since Fitbit uses the same app for their line of trackers targeted at children and adults, we only scraped the reviews that include one of the following keywords in their content: kid(s), child(ren), daughter(s), son(s), and Ace (as it is the name of the Fitbit children’s trackers). We conducted similar keyword searches for VF and CC as these apps are used for other trackers that we did not study.

For our research focus, it was important to analyze the user reviews that provide explanations beyond likes and dislikes, pros and cons, and problems and benefits. We were after reviews that are rich in terms of explaining the experience with the activity trackers. For this reason, we decided to code only reviews that 1) had more than 50 words on consumer electronics websites, 2) had more than 25 words on mobile application retailers’ websites, and 3) were in English. The word difference for two platforms was necessary as app reviews are known to be shorter than product reviews [18]. We also deleted all the duplicate reviews across retailers. During this process, we dropped a retailer (Dell) whose reviews were present elsewhere in our corpus. The distribution of reviews across retailers and trackers are listed in Table 1.

In total, we coded 2,628 user reviews, 1,789 of which were from consumer retailer websites and 839 were from mobile application retailers. One researcher followed the initial and focused coding procedures described by Charmaz [8] using NVivo 12. We initially open-coded the data, labeling issues faced with existing activity tracking technology (e.g., syncing problems, device fit problems),

Table 1. Total number of tracker reviews scraped and analyzed

	Tracker	Source	Rating	Scraped	Analyzed	Total
1	Advista Sports (AS)	Amazon	3.2	109	38	38
2	BingoFit Young (BFY)	Amazon	4.4*	325	110	110
3	Fitbit Ace (FA)	Amazon	3.6	255	67	95
		BestBuy	4.5	286	28	
		Walmart	3.2	4	0	
4	Fitbit Ace 2 (FA2)	Amazon	4.1	43	16	34
		BestBuy	4.5	106	15	
		Walmart	3.7*	3	0	
		Target	3.9	5	3	
5	Garmin Vivofit Jr. (GVJ)	Amazon	3.5	1,482	524	661
		BestBuy	4.4	363	63	
		Target	3.9	131	60	
		Walmart	3.3	38	14	
6	Garmin Vivofit Jr. 2 (GVJ2)	Amazon	3.7	599	207	431
		BestBuy	4.5*	464	149	
		Target	3.8*	476	12	
		Walmart	3.7	224	63	
7	Joy Octopus Watch v2 (JO2)	Amazon	3.5*	102	59	59
8	LeapFrog LeapBand (LB)	Amazon	4	753	154	211
		Walmart	4.4	136	57	
9	Trendy Pro (TP)	Amazon	4	1,033	150	150
						1789

*Calculated based on sales of multiple models

parent's experiences with activity tracking (e.g., a desire to track sleep, assisting children in sense making), children's experience (as described by their parents) with activity trackers and activity tracking (e.g., enjoying gamification, being motivated to reach milestones), and impact of activity tracking on individuals (e.g., feeling accomplished) and family (e.g., competing over tracked data). From these initial codes, we filtered and merged codes that were relevant to collaborative use of trackers in family life. During this process, the authors iteratively refined and discussed the codes and the emergent themes weekly as a team. Our final codebook included 24 codes grouped under 7 themes. We reached data saturation around 1,200 reviews, but continued coding all the reviews to make sure the experiences we observed were consistent across all trackers. While reporting our data, we included specific tracker names only for themes that present feature-specific (e.g. chore tracking) findings. The themes without trackers names apply to all trackers reviewed in our study.

3.3 Limitations

During data analysis, we gave special attention to addressing weaknesses outlined in other user review studies. Online user reviews can provide misleading assumptions regarding product's quality [35], users have a tendency to score and report extreme viewpoints [36], and developers can

Table 2. Total number of app reviews scraped and analyzed

	App name	Source	Rating	Scraped	Analyzed	Total
1	Utfit (UT)	App Store	3.0	1	1	1
2	CC Band (CC)	App Store	2.2	5	1	2
		Google Play	2.6	52	1	
3	Fitbit (FB)	App Store	4.2	500	1	101
		Google Play	3.6	100,000	100	
4	Vivofit Jr (VJ)	App Store	4.5	500	207	647
		Google Play	4.4	1,574	440	
5	Octopus Watch by Joy (OW)	App Store	2.9	38	32	80
		Google Play	2.8	75	48	
6	VeryFit 2.0 (VF)	App Store	2.4	141	34	8
		Google Play	3.2	3,421	5	
						839

potentially manipulate the reviews [34]. We tried to overcome these weaknesses by coding user's descriptions of their lived experiences with the devices, rather than their likes, dislikes, or opinions absent of experiences. In an effort to avoid misleading and extreme statements in reviews, our findings report on themes in the data which were expressed across reviews. Subsequent sections mention the frequency with which an opinion was specified in the reviews. Although it is possible that our data represent extreme viewpoints, these experiences can help to characterize problems that a broader group of users might experience if not addressed [9].

Reviews may also have been written early on in users' interaction with the technology. Our data suggests that reviews are not limited to initial impressions of and experiences with the technology. For example, we observed reviews with several updates suggesting how a family's experience with the product had changed. However, we acknowledge that the data may not fully represent participant's lived experience with trackers.

Our findings are limited to parents' perspective on the collaborative use of children-oriented activity trackers. Almost all of the reviews were written by adults. Previous studies showed the value of learning children's experiences through parents as they are being the "gatekeepers" of their children's data [49]. We saw that adults were explicitly commenting on their child's opinion with the product and differentiating between their and the child's perspective. This gave us the chance to report data on trackers' potential impact on children and parents based on parents' comments. Still, our study does not reflect children's perspective from firsthand, and we see this as a valuable opportunity for future work.

As far as we could discern, all reviews were from North American participants who are self-selected to create online reviews. Our data therefore only report on the natural experiences of users from a specific culture who shared their comments online. We do not capture or represent in-store purchases for products.

4 FINDINGS

We share our findings starting with parents' experiences and their comments regarding their children's experiences that are instrumental in uncovering the family-use practices of these technologies. We also describe challenges and concerns against the effective use of these technologies.

4.1 Overview of the Studied Children-Oriented Activity Trackers

The trackers included in the study are designed to be used by children starting at various ages, targeting children as young as 3 years old. Only two trackers define an age limit, 7 and 9 years old. All of the activity tracking solutions in the study are composed of a wearable wristband and an accompanying app and/or computer software. While the wearables are for children to carry, the app is mostly downloaded and used on parent's smartphone.

Trackers vary in collected health-metrics and features. Overall, the trackers for children collect less health-metrics than their corresponded adult versions. For example, only one solution (BFY) tracks heart rate and very few reports on distance travelled (AS, BFY, TP) and calories burned (AS, BFY, TP). On the other hand, some designs incorporate child-friendly features (e.g., chore reminders, games, rewards systems, challenges) to be more appealing to children. Most of these features serve as a motivation for children to be more active or to accomplish tasks.

The wearable and the app of a tracker are not always identical in terms of content. For example, in GVJ and GVJ2, the game, chore list, and sleep tracking features are only available in the app. For majority of the studied trackers, while the child can only access daily data, parents can see more historical data through the app.

4.2 Parents' Experience with Children-Oriented Activity Trackers

Parents' comments illustrate two main collaborative uses of trackers within families: for family informatics and for family life. For each use, parents reported diverse motivations.

4.2.1 Parents' Desire for Family Informatics. Parents' comments support previous knowledge from family informatics on the role that parents have in tracking their child's health and wellness [58]. Parents worry about their children's health and wellness, and want to encourage them to be physically more active. They see children-oriented trackers as a way to ease their worries as these technologies help them collaborate with their children towards family health management.

Starting a healthy life journey. We observed 200 instances in reviews where parents expressed positive feedback on trackers' ability to motivate their children to be more active. Parents worry that increased screen time and technology use may lead their children to live a more sedentary lifestyle: "My 11-year-old daughter is the type of little girl who loves to sit and watch tv or draw not too much the physical type" (BFY, Amazon, 2019). Parents felt the tracking devices could help promote more activity in the everyday life of their child. One review described, "This is an interesting device. It encourages movement, which we know is so important for children, and gives children positive reinforcement" (LB, Amazon, 2014). Some also believe if they can introduce more physical activity early in childhood, their children can have a chance of living a healthier life: "... what matters most is that she's motivated and that's a great start toward a healthy lifestyle later on in life for her" (GVJ, Amazon, 2017).

Parental desire to instill a healthy lifestyle as a family was explicitly mentioned 22 times in reviews. One review described, "We originally just got this to go with our own Garmin devices, to promote a truly healthy lifestyle for our whole family, but this goes way beyond what was expected!! This helps set the tone for a truly healthy way of life journey, beginning at a young age, by making this fun and rewarding!" (VJ, Google Play, 2019). They see exercise as a key component of instilling

a healthy lifestyle and want to teach the value of regular exercise to their children with introducing this as a family practice. In this process, they evaluate children-oriented trackers as an instrument to motivate children for being more active. In this sense, children-oriented trackers become a representation of the value that parents (not necessarily the children, which we explain in following sections) give to health.

Monitoring child's wellness and behavior. Parents monitored data reported through trackers as part of managing their children's health and wellness: "*I ordered this for my son to see how much exercise he is getting during the day*" (BFY, Amazon, 2019). Our data also shows that parents are not only interested with data that represent exercise. 73 parents reported using the devices to monitor their child's sleep data to make sense of their child's behaviors: "*It also helps me track her sleep pattern in case it corresponds to her mood at times*" (FA, BestBuy, 2019). There are parents who used the devices to learn about their child's activity while they are away: "*... it is great to see how active she is during school hours with all the 'concerns' these days about kids not moving enough*" (GVJ, Target, 2017). These use practices show, with wearing trackers, children are helping their parents not only to manage family health, but they also give access to information that parents cannot always observe. Parents gain "*a lot of insight into ... [their] child's daily/nightly activities*" (GVJ2, Walmart, 2019).

4.2.2 Facilitating Family Moments. Reviews mentioned multiple people in their household owning and using trackers 171 times, whether multiple siblings or children alongside parents. These shared experiences enable a new types of family interaction. Parents commented on the fun they have with daily step/activity challenges and/or data comparisons. For example, one review said about their child, "*he is always trying to compare his steps to mine or his mothers and we have little competitions which is fun for everyone*" (GVJ, Amazon, 2017). Another review agreed, stating that they "*enjoy having friendly competitions within the family*" (AS, Amazon, 2019).

In order for every family member to join this type of interaction with trackers, parents with more than one child described needing to buy a tracker for every child in the family (mentioned 117 times). When a child's tracker is malfunctioning or broken, that child feels being "*left out*" (VJ, Google Play, 2017). Reviews also include cases in which the trackers provide opportunities for children to interact with the extended family. For example, a grandparent who bought two trackers for their grandsons wrote: "*They report their activity numbers to me every day*" (GVJ, BestBuy, 2018). Another user wrote: "*... excellent app for parents and children to connect together and work towards mutual goals*" (VJ, Google Play, 2019). Families often used competition to encourage their children to activity levels: "*I am an avid runner and I am active in the outdoors. My son is more a tech nut and would rather sit playing video games. I picked this up for him so that I can gamify getting him out there. He absolutely loves the days when I'm stuck in meetings and he beats me, sending me taunts through the Fitbit app, and seeing his progress over time*" (FA2, BestBuy, 2019).

4.2.3 Trackers as Mediating Tools for Family Life. Users' comments indicate that families used trackers collaboratively to mediate aspects of daily family life. The trackers with chore tracking features (GVJ, GVJ2, and JO2) addressed family conflicts with becoming instrumental for educating children to take responsibility and for parents to ease their parental workload. Trackers without these features contribute to these aspects of family life with timers and alarms.

Keeping life on track. Reviews of trackers with chore tracking features (GVJ, GVJ2, and JO2) illustrated that these features decreased parents' negotiation with their children around schedules and tasks. Parents described setting chores and task reminders for their children, with 134 mentions that these systems were helpful. For example, reminders helped parents keep their children (as well as themselves) on task: "*It sends my wife and me reminders of what should be happening in the*

next few minutes to make sure our daughter is doing what she is supposed to be doing" (OW, App Store, 2017). Reviews also mentioned 56 times that trackers were useful for keeping children on schedule amidst busy times. For example, one participant said, *"I am a working mom. This watch really helps me keep track of my kids' schedules. I like keeping my kids active and mentally stimulated ... Especially on busy days, it's hard to keep track but this watch really helps me ..."* (JO2, Amazon, 2019). Reviewers also appreciated the dual role of the devices for activity and chore tracking: *"Aside from tracking her moves and steps, it helps me not to remind her of her chores like homework, cleaning up and even bedtime and waking up in the morning. Works great for knowing how active your child is and at the same time as a set reminder for chores"* (GVJ2, Target, 2019).

These quotes express two ways trackers are supporting parents. First, they mediate parent-child collaboration for meeting daily tasks and schedules. Second, parent's comments indicate that they are concerned about their child's development (e.g. mental, emotional) as much as their health. Parents want to make sure their child does the everyday requirements but also have extracurricular activities to stimulate their development. These activities can clutter parents' schedules which have already facing problems with work, home and personal life balance [3]. For these people, trackers serve as a tool to help children better meet the daily schedules.

Getting more help from children. In addition to being useful for keeping life on track, some parents appreciate that the chore tracking features of these devices (GVJ, GVJ2, and JO2) can encourage their child to *"help out around the house"* (GVJ2, BestBuy, 2018). Examples of helping around the house included making bed, cleaning the house, disposing the garbage, doing homework, and feeding the pet: *"When you do this in a routine, you have a cleaner house ... My eight and six-year-old kids love it and have helped me keep the house tidier on daily basis"* (VJ, App Store, 2018). Some parents described setting these as chores for their children through trackers. Other parents utilize the rewards systems in the GVJ and GVJ2 to motivate their child to help more at home: *"... yesterday I told them to come help unload all the groceries and I'd give them a [digital] coin. They jumped up excited to help and receive their coin"* (GVJ, Amazon, 2017). Thus, trackers with chore tracking and/or rewards features serve as a tool for family members to collaborate on daily housework.

Teaching responsibilities to children. Beyond a desire to decrease their workload, parents in 25 instances explicitly commented that, with mediating to keep life on track and to get more help around the house, activity trackers are also *"helping to develop healthy habits"* (GVJ2, Amazon, 2019). Users of GVJ, GVJ2, JO2, and LB described habits beyond health and wellness. Parents used adjectives such as *"self-sufficient"*, *"reliable"*, *"responsible"*, and *"independent"* while describing their expectations from their children. For example, one review said: *"I'm trying to assist my child in becoming more self-sufficient and I thought this would assist us greatly"* (JO2, Amazon, 2019). A user of the LB explained how the digital pet feature can teach *"children to care about others and to be nurturing and helpful"* (LB, Walmart, 2014). Reviews also described how the reminders functionality in GVJ, GVJ2, and JO2 could be used to promote independence: *"I like this as a gift because it's not a junky toy that ends up on the floor ... It encourages responsibility and self-reliance. No more asking how long until something happens"* (GVJ, Amazon, 2019). Independence is also practiced through the use of timers and/or alarms that are available in all trackers except LB: *"He loves waking up to the silent alarm"* (FA, Amazon, 2018).

These users' comments indicate that parents hope that activity trackers will help them raise children who not only exercise, but also are responsible and independent. Parents sometimes see teaching these qualities to their children as a challenging duty, as it is mostly practiced through verbally describing these traits to their children. Parents commented on finding trackers helpful in teaching child these qualities.

Addressing family conflicts. Activity trackers also addressed family conflicts through increasing the interactions that families had and increasing children's responsibilities. Rather than the parents nagging their children, the trackers motivate children to exercise, do tasks or chores, and meet schedules. According to parents, trackers "... really brought a lot of peace and cooperation ... with a little hint from the watch, but that is of course 10 times better than mom nagging" (JO2, Amazon, 2018). Trackers were reported to reduce conflicts within the family when they are used as an instrument for parents and children to be on a task (e.g. cleaning the house) 32 times in reviews. For example, one review described "it has decreased the number of battles around self-care tasks (brushing teeth, going to the bathroom, and picking up toys)" (VJ, App Store, 2018). This is because rather than parents telling children to do tasks, it was the device: "But suddenly there is no more fighting when it comes to bath time because it's the watch telling her its time, not mom!" (GVJ2, Walmart, 2019). This situation seems to alter children's perspective and motivate them to accomplish tasks.

4.3 Parent's View on Children's Experiences with Activity Trackers

To explore how children experience the collaborative issues, we analyzed the parts of reviews where parents explicitly wrote about their children's experiences with the trackers. We uncovered two common themes. Parents' comments indicate that children's experience with tracking technologies is also collaborative, although the nature of their experiences is quite different from parents. Children are not necessarily conscious of their parents' burden of tracking health, wellness, daily tasks, and schedules. They are motivated to use the tracking tools by the entertainment and independence that they provide.

4.3.1 Children Participating in Family Informatics. Children tend to take a more passive role than their parents in managing family health with the use of trackers. Parents' comments indicate that ownership of multiple trackers in a family and the family challenges motivate children to be more active as exercising can become an entertainment.

Owning trackers as a family. For the children who requested a tracker, parents indicated their children's main motivation was having a gadget like their parents and/or siblings. One review described: "... we love the watch and he loves having it - it's a watch AND an activity tracker, so he can be like mom and dad" (TP, Amazon, 2018). We observed that the child might own or ask for a tracker if either the parents or the siblings had already owned a tracker: "I ordered this product as a gift for my 10-year-old and he really likes it! When he saw me using my own to track my steps, he became interested in his own steps, he is so active with sports" (AS, Amazon, 2019). Device ownership even became a part of some family's identity: "My son loves his watch and we are a Fitbit family no doubt" (FA2, BestBuy, 2019).

Participating as a family. Ownership of trackers by multiple family members enable family challenges that are taking place over daily step counts or active minutes. Owning a tracker like parents and/or siblings enabled children to participate and compete with these people. Parents mentioned 71 times in reviews that their child being more active as they were motivated to compete with their parents and/or siblings.

With activity trackers, children get to "play in the challenges ... all do together as an extended family" (FA, Amazon, 2018). This makes exercising as a family fun activity and motivates children to compete with parents, siblings, and extended family through the health-metrics provided by trackers such as number of steps. Children were particularly excited about family competitions, "my son was so excited to get his own Fitbit to have step competitions with family" (FA2, Amazon, 2019) and particularly walking more than their parents: "They frequently ask us (parents) and each other how many steps, and they glow when they have more steps than us adults" (TP, Amazon, 2018).

The reviews suggest that children primarily see these family challenges as a family entertainment. However, in participating, they are also taking part in their parent's desire to instill health. Because of this reason, there are parents who call these type of family challenges as "*healthy competition*" (GVJ, BestBuy, 2017). With using activity trackers, children (mostly unconsciously) help their parents to collaborate on fulfilling the health expectations of the family.

4.3.2 Trackers Motivating Children to Collaborate more in Daily Life. Reviews suggest that trackers motivate children to practice independence, in line with their parent's desire for them to become more helpful at home and to meet daily schedules.

Feeling independent with trackers. The chore reminders and the timer features of trackers helped children manage their responsibilities. Children set timers by themselves so that they can engage in daily activities (such as brushing teeth, screen time, play time) without parent's intervention. 87 times in reviews, parents described that their children using reminders/timers to manage themselves, for example: "*The multiple alarms have also helped her to be more responsible and independent by waking up on time for school and setting reminders for herself*" (AS, Amazon, 2019). These use practices help children exercise and enjoy independence: "*The kids are extremely proud to be a little bit more independent and do like a grown-up (have a watch and decide 'themselves' when to do something ...)*" (JO2, Amazon, 2018). While making such a use from trackers, children are also helping their parents by taking off the pressure of meeting daily schedules and tasks.

Collaborating in daily life to enjoy rewards. In addition to practicing independence, children using GVJ and GVJ2 were also described being motivated by digital and physical rewards for collaborating on daily tasks and schedules with their parents. These trackers enable parents to assign digital (in the form of digital coins) and/or physical (redemption values for digital coins) rewards for each completed task. Parents reported on getting more help from their children around the house with the help of these rewards. For example, parents described 136 times in reviews that their children were excited to complete chores so they could earn rewards: "*They have been moving and active every day and are excited to help out around the house to earn coins. They brush their teeth and do their homework with a simple 'how would you like to earn some coins'*" (VJ, App Store, 2019). One parent even described needing to create more chores for their children: "*My kids are obsessed with earning coins. They actually asked if they could do more chores instead of going to bed. They love the loud beeping sound when they get a new coin (sounds are optional) and they are always trying to compete with each other. I had to add a bunch more chores to keep them happy*" (GVJ, Amazon, 2016). These reported experiences indicate the value of rewards as extrinsic motivators for children.

4.4 Potential Challenges around Using Trackers for Family Collaboration

Parents often struggled to effectively integrate activity trackers to family life. This is due to the device's dependency on an app. According to the parents, "*without the app, the watch is worthless*" (FB, Google Play, 2016). The wearable-app dependency raises two concerns for parents with younger children who do not own smart devices to for the app. First, existing design solutions are often unable to fully address parents' expectations on decreased parental workload due to the need for parents to take active roles for the system to fully function. Second, parents are concerned about the need to share their smartphones with their children for them to make the most use out of trackers.

4.4.1 Trackers Dependency on the Parent. Except LB, every wearable in our study requires a paired app to fully function, which reviews mentioned as disruptive or unpleasant 78 times. Although some features are only available on the wearable (e.g. timers in FA and FA2), some are only available on the app (e.g. games in the GVJ and GVJ2). Other features are available in both the app and device,

but functionality on the device is more limited. For example, the wearable of GVJ and GVJ2 do not show the full list of chores to complete daily and they do not allow to mark completed chores from the wearable. These limitations require parents to spend time managing the chores: “... even if the child remembers what chores they need to do on their own, the parent still has to go on the app to check them off on the list so the child can get credit for it ... that completely defeats the purpose and makes it annoying for everyone” (GVJ, Amazon, 2017). This dependence on the app to manage chores was mentioned 35 times in reviews.

All the wearables require periodic syncing with the app, and syncing problems were mentioned 218 times in reviews. Wearables store recorded information for only few days, while the app enables storage for infinite duration. If the wearable and the app are not synced regularly, the recorded information on the wearable is lost: “You have to sync it EVERY DAY, or you do not get the information. Who has time for that?” (GVJ, Amazon, 2017). Some parents complained about the wearables’ inability to show the correct time and date without being synced periodically: “... every few days we have to reconnect it to my phone to get the clock to stay on the correct time” (TP, Amazon, 2019). The syncing process do not always happen smoothly. As wearables pair with the app via Bluetooth, the wearable is required to be near the paired smart device in order to sync. Thus, the sync function does not work when the child is away. Some trackers (GVJ and GVJ2) occasionally require manual syncing with pushing a button on the wearable: “You have to be right near the tracker in order to re-sync the tracker to your phone. This means that you cannot view your child’s activity/steps/sleep/etc. unless you are right next to them ... That, in my opinion, is a design flaw with the tracker” (GVJ2, Amazon, 2017). Parents complained 68 times in reviews that the apps and wearables required their time and attention to sync.

The parents with younger children complained that they needed to assist their children in interacting with the wearable and/or the app. Some parents complain that they need to keep remembering to charge the tracker so that it is ready for use: “I only wish it could hold a charge longer, as I often forget to charge it, and it never fails that the LeapBand needs charging when the girls want to play with it” (LB, Amazon, 2014). Still others commented that their children who could not yet read or make sense of large numbers had trouble getting value out of the data reported through the wearable and/or the app. They questioned the possibility of this information being communicated with another strategy than numbers or percentages. One participant said, “For a 6-year-old who is learning to read time and trying to figure out what are all these things on the screen ... he wore it for a few hours and was excited to ‘see’ the numbers going up for step count, but I had to help him turn on the screen multiple times to show him where to find the steps, then to help him read the 3-4 digit number. He can read big numbers, but not that quickly on a small digital screen with other numbers and things catching his eye” (FA2, Amazon, 2019). For this parent, the device required them to help their child make sense of the step count and focus them on one of many pieces of information that the wearable was presenting.

Parents with multiple children wanted to easily track data from all their children and switch between viewing that data, mentioning 61 times in review the desire to easily manage a family account. In these cases, the parent needs to switch between accounts to sync each wearable and see data: “The app is also annoying to use with two kids. When you want to view each child’s steps for the day you have to log out, then log back in with your password to see the other child’s stats” (FA, Amazon, 2019).

These requirements further demonstrate the collaborative work required from parents (as app users) and children (as wearable users) during the use of trackers. They also highlight the negative impacts of this collaborative work on the family’s experience with activity tracking. The collaborative requirements typically cause parents to spend more time on the technology that they hoped to bring independence to their children. They complain that the trackers add at least another task as

well as cognitive load to their already busy lives with the need to sync, charge, mark chores, etc.: “*I don’t love that I have to remember to enter the app and mark things complete for him to get credits for them*” (GVJ2, Amazon, 2018).

4.4.2 Child Having Access to Parent’s Smartphone. The majority of the parents reported installing the paired app in their personal smartphone. Some parents let their children use their device to access their data or use features related to the trackers, such as games. However, parents mentioned 30 times in reviews that the need to share their phone caused them concern. There are three repeating reasons for these concerns. First, some parents do not want apps that are not directly associated with them taking up storage on their smartphone. One parent described that this situation as follows: “*Would love if my kids could use the family tablet to manage their steps and activity without cluttering up my phone! This is so irritating*” (VF, App Store, 2017). Second, some parents are concerned that their children might access other features or controls on their phone: “*... they would have to use MY PHONE to check their stuff off, and while they are in MY PHONE with full parental access to the app, who knows what they will mess with*” (GVJ, Amazon, 2017). Third, there are also parents who are concerned about the additional screen time that comes with the child’s access to games available in the apps of GVJ and GVJ2: “*The games are quite basic and my son got bored with it pretty quickly but that’s good, as we limit screen time*” (VJ, App Store, 2019).

5 DISCUSSION

Our results suggest that children and their parents have different motivations for adopting activity trackers in the family. According to parents, although children participate in family health management and collaborate with their parents on daily life, they tend to have different motivations from their parents for using tracking technology. Our findings suggest that children may not be conscious of the tracker’s intended contributions to family health and life. For parents, the trackers materialize contemporary parenting concerns and struggles. Existing designs cannot fully meet parents’ needs because the dependency between the wearable and app diminishes their goal of facilitating their children’s independence, requiring them to become active users of the children’s trackers. We relate our findings to prior literature on tracking beyond health and wellness, invisible labor, and the impacts of technology use on family life.

5.1 Family Tracking Practices for and beyond Health and Wellness

Modeling adult versions of trackers, existing children-oriented activity trackers are typically developed to promote health and wellness [25]. Similarly, children’s use of activity trackers and their activity tracking practice have been mostly studied from a health and wellness perspective [41, 49, 63]. Our findings support previous work and demonstrate that many parents intend to use the technology to promote healthy lifestyles. However, our data also illustrate the use of activity trackers with chore functions beyond health management. Trackers are also expected to help children better participate in daily life and keep up with schedule.

Our data demonstrate that parents utilize trackers to monitor their child’s activity, but their use is not limited to this goal. Parents engage in family challenges with their children. They compare tracked health metrics at the end of the day to see who has done more. These use practices overlap with Grimes et al.’s [26] finding that parents want to be good models for their children. From this perspective, trackers become a tool to communicate the value of health and wellness to their children and to promote a healthy lifestyle as a family. However, parent’s comments indicate that children’s main motivation for using an activity tracker is not necessarily tracking their health and/or wellbeing. Instead, parents explain that their children often used trackers as a source of entertainment, to feel independent, or for social bonding with their parents. Parents report that

family challenges and rewards, most of which are extrinsic, are aligned with children's motivation to have fun. Saksono et al. [60] suggest that these extrinsic motivators can be internalized by children if satisfying moments are produced with parent-child engagement. Our data suggests that commercial children-oriented trackers may be helping to produce these satisfying moments and positively contributing to family health management.

User's comments also show how parents further utilize activity trackers in family life to address dilemmas. Our work suggests that parents want to do their best for their children. They try to support their child's physical, mental, and emotional development. However, their comments also illustrate their struggles in incorporating these tasks into their busy life routines. Working parents commented on challenges of maintaining with work-life balance. Parents with more than one child shared stories on their struggle to manage schedules of multiple kids. Children-oriented activity trackers were expected to address some of these workload and burden dilemmas parents face by promising to motivate children to participate in daily tasks and/or schedules through rewards and instilling independence. Parent's comments suggest that trackers encourage their children to carry out chores without parental reminders and better meet schedules.

A common point of these family use practices (i.e., use of activity trackers for family health management and meeting daily tasks or schedules) is the desire for parents to teach their children about responsibilities. Previous studies on technology use in family life reported parents' similar concerns for raising a disciplined and responsible child with the help of technologies such as mobile control apps [22] and parental rules [30]. However, these technologies are typically structured around restricting the actions that children can take. Children-oriented activity trackers differ from these examples by providing opportunities for parent-child to collaborate towards family health and daily life management. This finding is in line with conclusions reported in other studies [57, 60, 63] on the efficacy of technology probes for motivating children to take active role towards family health management and the parents' wish to raise a responsible child [3, 57]. Thus, activity trackers for children materialize parents' desire to raise responsible children who participate in family health management and daily life.

5.2 New Invisible Work for Parents

We described how commercial children-oriented trackers enable parent-child collaboration towards health management and daily life/schedules. This collaboration is more significant for parents as the technology enables them to share the workload and burden with their children and still enable them to practice ideal parenting. However, our findings also show that the use of trackers do not fully address parents' expectations. Instead, they reinforce new type of work, burden, and concerns to parents.

We noticed that parents had to take two new forms of invisible work - the work that is not visible but taken by granted by others [69, 71] - due to the design of these activity trackers. First, the wearable of the trackers require attention from parents as children cannot do some tasks because of their age. For the wearables that require charging, parents need to remember and charge the wearable periodically. Parents also assist children in making sense of their tracked data that are reported in numbers which are hard for children to read or interpret. This set of tasks are mainly to make sure the wearable devices function property, so that the data can be collected from children to fulfill the promises of these devices and meet parents' expectations.

Second, beyond the physical devices, the wearable-app design also requires parents to participate in taking care of the wearable-app relationship and the tracked data. As the app is mostly available on the parent's smartphone, parents are responsible from the initial setup of the wearable, app and chore lists. The wearable needs to be synced with the app in order not to lose data. This sync process varies by tracker. It is sometimes manually triggered or requires the wearable and the app

to be near. Children are unable to see their historical data from the wearable, as more complete data is often only available through the app. The parent needs to ask and mark the completed chores every day. As such, children's limited access and use of the app forces their parents to take on additional invisible work of making the ecosystem work and enabling the children to interact with the app.

We found these new, invisible tasks create frustrations for parents. Although they expect the trackers to decrease their burden with better collaboration with their child towards health management and daily tasks/schedules, this goal is not possible without their active participation to make the ecosystem function. From this perspective, the use practice of children-oriented activity trackers introduce a new form of collaborative effort into families that is different than collaboration towards family health informatics as described by Pina et al.'s [58]. Parents with younger children should take active roles in the use of children-oriented trackers. While parents hope to address a part of their parental workload and burden with trackers, their negative experiences indicate that the use practice of trackers require a different type of parental work. Thus, it is not possible to report that existing design solutions eliminate parenting burden. Instead, they create interdependence between the children and the parent over the use of trackers which results in additional stress for parents.

Our data adds to Jørgensen et al.'s [41], Grimes et al.'s [26], and Pina et al.'s [57] findings on parents' concerns regarding the use of tracking technologies within families. Distinct from Grimes et al.'s [26] and Pina et al.'s [57] studies, parents did not comment on concerns regarding sharing their own data with their children through family challenges. We suspect that the design of children-oriented activity trackers focuses attention on children's data rather than the entire family, preserving parent's privacy and control. On the other hand, we found that children-oriented activity trackers introduce new concerns for parents beyond the sedentary lifestyle concerns reported by Jørgensen et al.'s [41]. There are parents who do not want to share their smartphones with their children as they see these as their personal belonging, as they do not want their children to have access to the app with parental controls, and as they considered app interaction as screen time. These aspects of children-oriented activity tracker use can add additional burden and mental load on parents.

5.3 Tracker-Mediated Family Life

While serving as an instrument for parents and children to collaborate towards family health management and daily life, children-oriented activity trackers also contribute positively to digitally mediated family interaction. According to our data, this type of interaction was not an initial motivation of parents during the introduction of children-oriented trackers in family life. Instead, it naturally emerged during the use practice. We observed two types of positive impact of trackers in social aspects of family life.

First, our findings are in line with Gram-Hansen's [25], Grimes et al.'s [26], and Saksono et al.'s [60, 63] comments regarding the positive impact of activity trackers and activity tracking on family interaction and dialogue around activity challenges and daily count comparisons. Parents' comments show that there are families with multiple family members' using trackers. Tracker ownership as a family introduces a new interaction channel in the family. Supporting Saksono et al.'s findings [60], parents get the chance to feel satisfied with teaching their children about the value of health while competing with their children. This use practice does only promote family health and wellness but also enables bonding moments [60, 63] between parents and children with turning exercising to a fun activity.

Positive interactions around trackers are not limited to parent-child relationships. Families with more than one child buy a tracker for each child. This tracker ownership enables and reinforces social interaction among siblings over trackers and the tracked health metrics. For this reason,

our work indicates the extension of bonding moments beyond parent-child dyads. Some parent's comments also indicate the impact of these bonding moments on the larger family as children and other relatives get the chance to talk and/or compete without necessarily living in the same house.

Second, we found that trackers occasionally take the parent's role of setting rules. For example, rather than a parent limiting the child about a screen time, a timer can be set on the tracker to manage this deadline. Similarly, parents can transfer the responsibility of reminding chores to the tracker. These are known as factors creating tension between parents and children [5, 30]. Parents reported the potential of trackers to decrease family conflicts resulting from setting rules. They are happy about not having to nag their children to do tasks and be on schedule. As children can do tasks without interacting with their parents, they feel accomplished and independent. With addressing different expectations of each family member, children-oriented trackers have the potential to positively impact parent-children relationships by decreasing family conflicts on tasks and schedule. Parents commented how the devices could help to bring peace to family life.

5.4 Design Implications

Our review of family use practices suggests a few main challenges in the design of current children-oriented activity trackers. First, current children-oriented activity trackers are designed around the concept of health tracking as practiced with adult versions of activity trackers [25]. Thus, they primarily reflect an individual use practice for health management, aiming to support self-reflection and action based on collected data. However, our findings support results from previous work [26, 63], highlighting the significance of family challenges engaged via trackers. These competitions do not only motivate children to be more active but also promote a new type of social interaction within family [60]. From this perspective, even though the design is based on individual use, the use practice of trackers towards health management is structured around collaborative use.

On the other hand, the chore feature of trackers was designed towards collaborative use, but our findings indicate users desire to practice individual use of these features. Parents appreciate trackers with the chore tracking feature for their ability to teach children towards being self-sufficient and responsible. Children were commented to enjoy these features to exercise independence. However, the current chore tracking features were developed around the limited agency of children and the active participation of parents through coordinating chores via app. Thus, while the users want to practice independence, the system requires parent-child dependence.

A possible way to address these discrepancies between use practices and the current design solutions is the design of these systems towards co-use practices within families. The app can be redesigned as an educational tool for parents and children to sit down and review tracked data, set goals, define schedules/tasks and mark completed ones. Previous technology probe designs communicate the possibility of addressing family use with such bonding opportunities with educational content [60] and family-friendly interface solutions [57]. A shift from digital or physical rewards to education-oriented bonding moments structured around app co-use might also mediate children's internalization of daily responsibilities.

Designs could also further support children in self-monitoring their own activities and chores, but enable deeper consideration of trends in the data or results of competition with the assistance of parents. This idea can be reinforced with more independent chore tracking capabilities offered through wearables. Using easy-to-interpret icons, children can better track chores, schedules, mark completed ones over trackers, and reflect on the day with co-using the app with parents. Given the wide range of ages that activity trackers appear to support, it may be helpful to incorporate settings which trade off visualizing tracked data in detail for more interpretable representations. For example, having modes on wearable devices which enable comparisons between family members

or friends for an older child as well as a mode which presents an abstract representation of activity (a la UbiFit garden [12]) instead of a large number.

The redesign of the companion app around family use might also address the mixed message communicated through current app designs regarding its user. The apps are presently designed as though children are the targeted demographic through the use of graphical avatars and icons. However, the functionality is often only available on parent's smartphones (especially for parents with younger children) as required by the Children's Online Privacy Protection Act. If the apps are designed as an instrument for family co-use, they might better support family use practices with turning the collaborative effort necessary to make these technologies to fully function into a health/responsibility education activity.

6 CONCLUSION

Our qualitative analysis of user reviews of 9 commercially available activity trackers for children reveal two types of collaboration that is necessary for the use of these technologies in families. With the help of trackers, parents and children collaboratively work towards to family health management and daily tasks/schedules. At the same time, the design of the children-oriented trackers requires parents to facilitate their child's interaction with the wearable and the app. This results in new invisible work for parents who want to use the technology to facilitate raising a responsible or health-conscious child. On the other hand, trackers introduce new interaction dynamics within families that enjoy family challenges. In this sense, commercial children-oriented trackers have both positive and negative impact on family life. Although trackers positively impact family life with increased interaction and communication, they also negatively affect children and parents with their interdependency to each other during the use of the technology.

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