

Snack Buddy: Supporting Healthy Snacking in Low Socioeconomic Status Families

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ABSTRACT

We conducted a 12-week comparative field trial with 20 low socioeconomic status (SES) caregivers from 10 families to explore their use of a sociotechnical mobile application designed to promote healthy snacking, Snack Buddy. Our analysis of the semi-structured interviews, pre/post-intervention instruments, and photo-elicitation interviews suggests that participants gained a greater awareness of their own snacking practices and those of their family members. Users were empowered to adjust their own practices and beliefs around healthy eating because they were more aware of their family's snacking behaviors. We describe the unique social dynamics of how families engaged with each other and the application, which includes positive social support for healthy eating. By providing insights into family interactions and experiences with the application, we identify benefits, challenges, and strategies when designing family-level sociotechnical interventions for healthy behavior.

Author Keywords

Low socioeconomic status population, family, healthy eating, mobile health, field trial

ACM Classification Keywords

H.5.2 User Interfaces: User Design

INTRODUCTION

Low socioeconomic status (SES) populations can benefit from sociotechnical interventions that promote healthy behaviors because they have increased lifestyle-based risk factors for obesity and chronic illness [2]. While there are many sociotechnical interventions for managing dietary behaviors [35, 41], there are few that account for the lower health literacy levels and socio-cultural needs of low SES populations [13]. Research interventions for low SES populations range from interactive multimedia nutrition education programs [34] to shared experiences facilitated by mobile technology [17, 33] to mobile chronic condition management [13]. These successful interventions motivated us to

consider how we could use mobile technology to empower low SES individuals to improve their eating practices.

Researchers have documented the tractable and intractable issues low SES populations face when attempting to improve their diets – including their overall sense of not being able to control their diets [25, 28]. Contrary to the perceptions faced by low SES communities, Grimes et al. showed that even in low resource areas, people can find healthier dietary alternatives [17, 33]. This work helped people find healthier alternatives, however there is a need to support people in integrating those healthier foods into their lives and previous research suggests social support plays a role in making change [41].

Although some low SES individuals were motivated to share healthy eating ideas within their community [17, 33], other researchers detailed how low SES individuals were hesitant to share dietary information with neighbors [28]. We aimed to facilitate support from a trusted social support system – the family – where individuals would feel more comfortable sharing information [24, 28]. Families are a constant dietary influence in low SES populations [25] and leveraging family dynamics can support healthier behaviors [12, 19].

We build on CSCW and HCI research in facilitating social support for healthy eating by addressing the specific needs of low SES families. We accomplished this by developing Snack Buddy, a novel Android mobile application, that provides low SES families the ability to track their snacking, receive feedback on the healthiness of snacks, and review the snack healthiness of family members through interfaces designed specifically for their family role and demographics. We scaled the problem from dietary management to snacking management because snacking is a major issue in low SES diets [25] and electronically managing one's entire diet is burdensome [13]. We deployed the application in a 12-week field trial to understand how families used the application. We used semi-structured interviews, photo-elicitation interviews (PEI) [10], and application log data to explore how participants used the application and engaged with their family members. The specific contributions of our research are:

1. An understanding of how low SES families use mobile applications for healthy eating in their everyday lives;
2. Identifying the benefits and challenges of family-level sociotechnical interventions for behavior change; and
3. Potential strategies for designing mobile applications that engage the entire family in adopting healthier behaviors.

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RELATED WORK

Sociotechnical interventions that aim to change eating behaviors [13, 29, 35, 41] typically focus on individuals and miss key social constructs that influence behaviors. Tsai et al. developed PmEB, a dietary monitoring application on a feature phone, for individuals to improve their weight management [41]. Connelly et al. designed a mobile dietary application to assist low literacy individuals on dialysis monitor their restrictive diet [13]. Mamykina et al. designed MAHI to help people with diabetes understand the link between what they consumed and their blood glucose levels through mobile phone pictures, a glucometer, and an online website [29]. MAHI participants received feedback from an educator, but the intervention was focused on the individual. Although these interventions were mostly well received by participants and affected behavior in some instances, they did not leverage social support structures that significantly influence behavior change [8, 21]. The few sociotechnical interventions for dietary improvement that included social support structures [17, 33] were designed for sharing and reflection with the greater community and among peers. We focused on a specific, structured social unit to support behavior change by designing with and for families – a different social dynamic because parents and children are typically not considered peers within the home.

A significant body of research suggests that family-level factors are some of the most significant determinants of health behaviors. Family eating patterns, behavior modeling, and family meals all influence children's eating behaviors [39]. Parents' eating behaviors are influenced by pressure to maintain a healthy family and social support within the family [38]. The CSCW and HCI community has primarily focused on enabling communication and information sharing between family members [3, 23], however less work has been done to understand how to facilitate social support of behavior change among family members.

Grimes et al. studied how to support family reflection on health behavior, which provided insights into the design space for family support of healthy behaviors [19]. The potential of engaging the family illustrated by this work motivated our approach and informed our system design. Colineau et al. [12] designed one of the few sociotechnical interventions that influence health behaviors in the entire family. They designed a web portal to facilitate shared reflection and tracking of any healthy behavior that families wanted. Users viewed how family members performed on attaining their individual and collective health goals. Our intervention differs in that we use a mobile phone intervention as opposed to a web portal because low SES communities prefer and have greater access to these devices [25]. We also focus on a single behavior, healthy snacking, to simplify data entry, visualization, and lifestyle change focus.

HEALTH BEHAVIOR THEORIES

Researchers in the HCI and CSCW community utilize health behavior theories to enhance sociotechnical interventions for behavior change [8, 27]. These theories provide organizing frameworks for our understanding of human behavior and in-

form intervention design. We primarily used two theories in the development of Snack Buddy – social-cognitive theory (SCT) [4] and transportation theory [16]. SCT posits that behavior is determined by an interplay of social and cognitive factors. The key construct in SCT is self-efficacy, which is an individual's belief in her control over her actions and capability to perform a specific behavior. SCT includes other concepts and two that are relevant to our work include sociostructural factors – facilitators (factors that support behaviors) and impediments (factors that prevent behaviors) – and outcome expectations, which are beliefs about the consequences of behaviors. Transportation Theory, the second theory that informed our design, suggests that individuals' beliefs and attitudes are affected whenever they engage in an immersive narration [16]. The decisions people make during the narrative induce behavior change after they leave it.

METHODS

We used an iterative, user-centered design process to develop an Android application for healthy snacking, *Snack Buddy*, that included two years of needs assessment studies, one year of prototyping studies, one development year, and finally one year for the pilot study; the latter we report in this paper. The intervention design was motivated by our previous research exploring the use of mobile applications to support healthy snacking in low SES communities [24, 25] and was intended to facilitate interactions among family members using the application, who were primary and secondary caregivers. Primary caregivers are typically parents who provide the majority of care for their family including cooking, cleaning, shopping, and providing income. Secondary caregivers are older teens in the family who help cook, care for their siblings, and assist with chores. Our previous research identified this family structure as prevalent within our target population [25].

Application

Based on our user needs assessment and prototyping studies, we developed Snack Buddy to provide users with the ability to enter snacks, receive healthier snack suggestions, view their personal snack history, and compare their snack healthiness with other family members. When users entered a snack, they received feedback about its healthiness based on the Fooducate database in the form of 0.5 to 5 stars [1]. Healthier snack suggestions were typically the same type of food (e.g., salty snack) and within 1 star improvement from what was input to facilitate small, manageable improvements. Participants could create a new snack if it was not in Snack Buddy. A research team member would add the snack, its image, and its healthiness rating to the server side database and push the update to all Snack Buddy users. We did not include price information in the application because our prior work suggested that low SES users do not want price information [24].

We designed the application with two different, demographic-targeted interfaces to meet the distinct design preferences of both primary and secondary caregivers. The participants could use either of these interfaces, however each interface was designed specifically for one caregiver type – the *Informational Interface* (Figure 1A and B) for primary caregivers

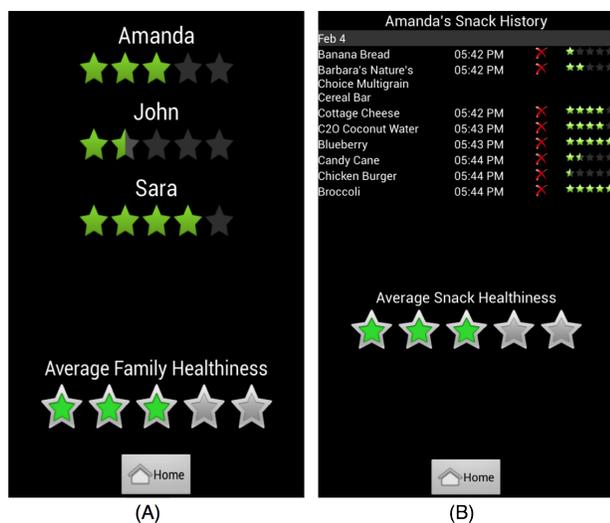


Figure 1. Interfaces for the home screen (A) and snack history screen (B) of the informational interface

and the *Gaming Interface* (Figure 2A and B) for secondary caregivers. The informational interface was designed to support primary caregivers' management of their family snacking and prioritized simplicity in providing snack healthiness information. Primary caregivers had the ability to view the detailed snacking history of all family members, while secondary caregivers could only see the overall, average snack healthiness of their family members. We made this design decision because, in our previous research, primary caregivers suggested that they needed more information about their families' snacking behaviors to make improvements and they were concerned about altering family power dynamics if their dependents also had this data.

The gaming interface provided a narrative-based game where users could select a human avatar and progress through that character's life goals based on their snacking healthiness. Users helped their avatar get an education, attend college, and buy a house, by getting more snack healthiness points. For example, they could eat healthy snacks to get 20 healthiness points and buy their avatar a calculator. The purchase helps the avatar earn the 65 points required to progress from primary school to college. Snacks were worth between one (e.g., Hot Cheetos) and ten (e.g., carrot) healthiness points. The narrative game was informed by informal conversations with young people in the community who regularly talked about how they wanted their lives to be different – they hoped to go to college, get a job, and own a home.

Our design of both interfaces and the underlying application was informed by SCT in that we designed features that were intended to enhance self-efficacy, socio-structural facilitation from the family, and outcome expectations. Snack Buddy was designed to increase self-efficacy through: (1) positive, vicarious experiences by providing family members with the ability to see and learn from each other's snacking progress and (2) reflection on their personal experiences via their personal snacking history. Snack Buddy also promoted self-

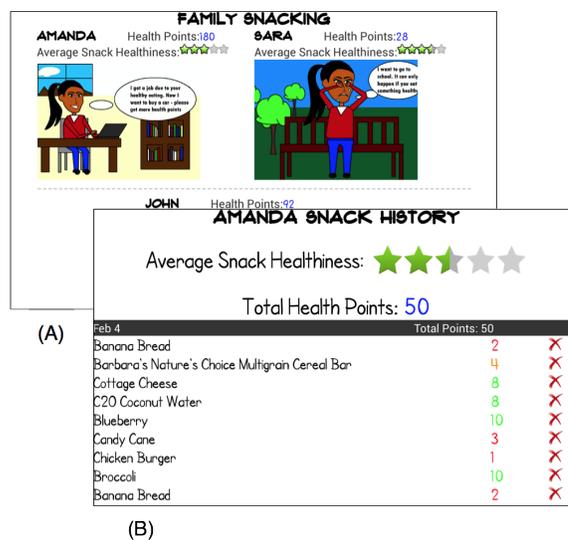


Figure 2. Interfaces for the home screen (A) and snack history screen (B) of the gaming interface

efficacy by providing small, actionable recommendations for healthier snacks that users could deliberate and act upon. We aimed to enhance a key socio-structural facilitator, the family [12], by providing individuals with the ability to view family members' aggregate snacking healthiness. We provided users with abstract, star-based feedback on the healthiness of their snacks, which they were easily able to understand, to help them develop outcome expectations of how specific snacks would affect their health.

Transportation theory informed our creation of a long, narrative game in the gaming interface where the user develops a long-term relationship with their virtual avatar who has a relatable life, as opposed to a short, single play game such as OrderUP! [18]. The avatar's ability to progress through life was directly affected by the eating behaviors of the user, mapping the narrative to their snacking choices.

Our lab members used Snack Buddy for one-month before deployment to identify and fix interface issues. During this time we also improved the snack input mechanisms by adding voice-input and predictive type to make the process easier.

Study Design

We conducted a twelve-week field trial with twenty participants from ten families; each family had a primary and a secondary caregiver participant. Five families (10 individuals) were assigned to the intervention group and five families (10 individuals) were part of the control group, which was intended to control for behavior influences outside of the application and effects of study participation, such as interaction with researchers and data collection methods. Each participant received \$120 for participating in the study – \$60 Walmart gift cards were distributed during weeks six and twelve. We received human subjects research review board approval before recruitment.

The field trial, as shown in Figure 3, consisted of eight meetings over the twelve weeks. At the first meeting, individuals

completed a background questionnaire, a snacking awareness survey, and a produce availability questionnaire, the latter two were informed by validated instruments [15, 26]. All participants also completed the surveys after the intervention period to assess pre/post changes. We acknowledge that it is impossible to know exactly what participants ate without invasive technologies, however we used a mixed methods approach to get a more accurate picture of participants' eating habits.

After the first meeting, all participants, those both in the intervention and control groups, were instructed to take pictures of the food that they ate for one week as part of the photo-elicitation interviews (PEI) [10]. In this study, we used PEIs as a method for gathering data on intervention and control group eating behavior. The PEIs were not a component of our intervention, though we acknowledge that using this method provided an opportunity for behavior reflection separate from the intervention components. At the end of the first week, we conducted the PEI with participants, which were semi-structured interviews where we asked questions about the pictures they took. We reviewed each picture with participants and asked them to describe the food and the context around eating it. Although the focus of the PEIs was the specific foods that they ate, broader issues around healthy eating and family influences often came up, which we captured.

After completing the PEI, participants were purposively assigned to the intervention group or control group in an attempt to balance gender and ethnicity. The intervention group was trained how to use the application and then instructed to use it to monitor their snacks for four weeks, while the control group returned to their normal activities for four weeks. The researchers were not actively part of the intervention and only interacted with participants, from both groups, to collect data by administering surveys and conducting interviews. Midway through the four-week intervention period, we met individually with all participants. We met with the intervention participants to capture their early experiences using the application while it was fresh in their minds and we met with the control group to ensure the same amount of contact for both groups.

After the four week intervention period, we met with all participants, both in the intervention and control groups. At this time we conducted another semi-structured interview with the intervention group about their experience with Snack Buddy. All participants were again instructed how to do a week-long PEI study so that we could track their eating behavior post-intervention. Following the post-intervention PEI, participants began a 6-week follow-up period where they met with researchers at 3 time points to complete 24-hour food recalls. Across the 12-week study, we conducted a 24-hour food recall at each of the eight participant meetings (see Figure 3). The 24-hour food recall is a validated food-survey method [31] used in nutrition-related research where we asked participants to identify all the foods and snacks they ate during the 24-hours before the meeting, with the goal of gaining insights into their eating behaviors [32].

Participants

We recruited participants in collaboration with the Bridge Project, a community outreach program that provides aca-

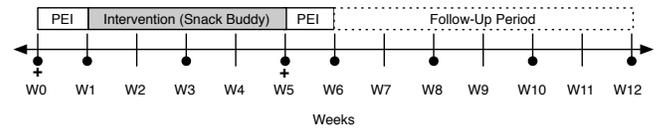


Figure 3. 12-week field trial study design: The intervention and control groups participated in the PEIs (2 total) and 8 meetings (noted with a •). Meetings included a 24-hour recall. We conducted 2 semi-structured interviews about application usage with the intervention group at W3 and W5. Meetings that included surveys are noted with a +. The intervention group used Snack Buddy in the intervention period.

ademic support to K-12 children from 500 ethnically diverse families in Denver public housing neighborhoods. In 2013, 72% of the children qualified for free and reduced lunch. We selected this population because previous research showed that 87% of the children in this community were at risk for a chronic illness [7]. We built a rapport with the community by volunteering over 100 hours tutoring children.

Both the intervention and control group had 5 female primary caregivers and no male primary caregivers. Both groups also had 4 female and 1 male secondary caregiver. In the control group, 4 participants were Hispanic, 4 were White, and 2 were African American. In the intervention group, 6 participants were Hispanic, 2 were White, and 2 were Asian. Primary caregivers ranged from age 32 - 58 ($M = 43.4$) in the control group and from age 31 - 46 ($M = 40.4$) in the intervention group. Secondary caregivers ranged from age 12 - 18 ($M = 13.8$) in the control group and from age 13 - 15 ($M = 14.2$) in the intervention group. Four primary caregivers in the control group owned mobile phones, while all five of the primary caregivers in the intervention group owned mobile phones. Four of the secondary caregivers in the control group owned mobile phones, while two of the secondary caregivers in the intervention group owned mobile phones. There were no statistically significant differences between groups in any demographics.

Analysis

The data generated from the field trial included: (i) pictures from the pre- and post-intervention PEIs; (ii) pre- and post-snack healthiness and awareness surveys; (iii) 24-hour food recall data; (iv) intervention group participants snacking information recorded by Snack Buddy; (v) Snack Buddy usage patterns; and (vi) semi-structured interview videos. We used an inductive, qualitative analysis where the research team open-coded transcribed recordings of the PEIs and semi-structured interviews to identify emergent themes, which were then discussed and iterated on to develop key, high-level themes. We report on themes related to application use and family interaction in this paper, which primarily emerged from the semi-structured interviews with intervention group participants. On an exploratory basis, we analyzed differences between and within subjects using paired t-tests and analysis of variance (ANOVA) for snack awareness survey responses and produce availability survey responses. We controlled for baseline survey responses in our analyses.

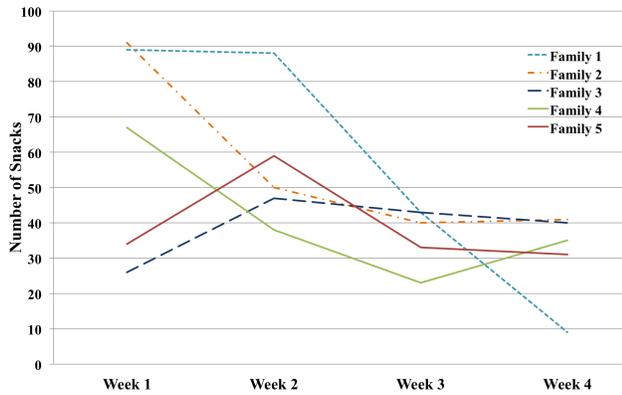


Figure 4. Average number of snacks entered per week by family. During week 4, Family 1 reported having a family emergency, accounting, in part, for the sharp decrease.

FINDINGS

In this section we report on the patterns of application usage by participants, followed by a focused exploration into how participants used specific, family-focused features, such as messaging and the demographic-targeted interfaces. This exploration provides insights into how the family members engaged with each other through the intervention. Next we examine families' health behavior awareness and interactions surrounding the application. We primarily report on the experiences of the intervention group because they were the group that used the application.

Application usage

Intervention group participants used the application consistently during the intervention period. Over the four weeks, we found that participants used Snack Buddy nearly every day – an average of 6.8 days during week one, 6.4 days during week two, 5.7 days during week three, and 6.3 days during week four. As shown in Figure 4, we found a decrease in the number of snacks entered by most families across the four week intervention, which may reflect a “Novelty Factor” [13] of using the application or a conscious decrease in snacking, as some participants reported. But even during the last week, participants still entered an average of 2.63 snacks per day. Figure 4 shows that, around week three, families converged on entering a similar number of snacks per week – between 30 and 40 snacks per week. Family 1 was an exception because they experienced a family emergency in week four.

Participants enjoyed using the application so much that PC2¹ and PC5 asked if they could have the application on their phones to continue using it. Similarly, secondary caregivers inquired if the application was on Google Play. When we asked about future Snack Buddy use, SC1 remarked, “*I would like to see this application out on mobile phones. This application was good ... I tried some other apps on Google Play, but they weren't as good as this one*” (M4).

¹PC[#] indicates a primary caregiver and SC[#] indicates a secondary caregiver. Participants with the same number were from the same family (e.g., PC3 and SC3 are from the same family). M[#] indicates the meeting number.

Use of the demographic-targeted interfaces

We asked which Snack Buddy interface participants preferred since participants could switch between the informational and gaming interfaces. Generally, all caregivers preferred and used the interface designed for them – parents used the informational interface and teenagers used the gaming interface – even though most tried both interfaces. Participants rated the ability to switch between the two interfaces as the least useful feature in the application, suggesting that the separate interfaces appropriately met their needs.

The primary caregivers did not express interest in gaming. After using Snack Buddy for two weeks, PC4 said that she just preferred the parent interface, “*I didn't use [the gaming interface]. I did switch over and kind of looked at it, but I didn't mess with it. I preferred the [informational interface]*” (M4). PC2 also mentioned, “*I didn't use the game because I don't know how to do games. I'm lucky I know how to use the phone.*” (M3). Most primary caregivers felt less confident using smartphones and perceived the gaming interface as more complicated which, in part, led to their hesitance in using that interface. Primary caregivers also stuck with the informational interface because it met their needs. PC1 explained: “*I just did the parent one. That was fine. I liked seeing the stars, and be like 'oh, okay I'm doing a good job'*” (M4).

Secondary caregivers preferred the gaming interface because it was “fun” and “cool,” while the non-gaming interface was “dull” and “boring.” SC4 noted that, “*I went to [the informational interface] like once ... it wasn't really as cool ... I don't know, I thought the game one was more fun*” (M4). The game engaged and motivated secondary caregivers to eat healthier foods: “*I like the game status, it shows me what I have already earned. It motivates me to keep going*” (SC5, M3). SC1 exemplified how the gaming interface engaged secondary caregivers – he entered 23 snacks in week three, beat the game, and then entered just 4 snacks the following week. A family emergency in week 4 may have compounded his decreased input.

Messaging feature use

Snack Buddy provided users with the ability to send messages within the application to their family members to support dialogue around healthy snacking. As one of the features intended to support family engagement through the application, we investigated how participants used it. In total, forty-one messages were sent by the caregivers during the four-week intervention phase. These messages generally revolved around participants' everyday lives. For example, PC2 sent to SC2: “*hi did u do good at school today.*” They also used messaging to discuss healthy eating and remind each other to enter their snacks, for example PC4 said to SC4, “*your dad text me and will be there for the kids. have a good day. Enter your snacks today.*”

The majority of messages – 85% – were sent during the first week. Many participants told us that they tried the messaging feature when they first received the application, but then either forgot about it or felt like it was not useful: “*I used it a couple times, I remember like, a long time ago ... I*

would say how are you doing that, and like okay. I think I've had enough time with the [messaging]" (SC3, M3). The messaging feature was not regularly utilized by participants and overall was perceived as not useful, especially when families had access to SMS text-messaging on their phones and discussed the application and food choices in person.

Family interactions and engagement

We designed Snack Buddy to engage the family as a unit in moving towards healthier eating. Family members described how their eating practices were intricately tied to their family and that they ate healthier when eating together with their family. Primary caregivers acted as the gatekeeper to much of the food and snacks that their children ate, however there was a significant amount of collaboration between family members in deciding what foods to purchase and prepare. Our findings highlight the importance of the family in healthy eating and suggest that our application engaged the family in novel and meaningful ways. Here we describe the ways that family members engaged with each other during the study and how the application played a role in those interactions.

Family Awareness

Family awareness was an important concept that participants identified in our study. We found a difference in self-reported family snack awareness between the pre- and post-questionnaire that approached significance, $t(9)=1.87$, $p=.095$. Our qualitative data supported this finding – participants reported feeling more aware of their family members' snacking behaviors and suggested that the application increased their family-level snacking awareness. Family awareness was not just an abstract concept that participants identified; it provided tangible benefits, such as helping plan meals and facilitating social comparison, which differed between primary and secondary caregivers.

For primary caregivers, increased family awareness was useful in two ways: 1) it decreased their level of concern about what their children were eating and 2) helped them plan, prepare, and purchase food. First, primary caregivers were comforted that they had the ability to track family snacking because they often did not know what their children ate throughout the day. For example, PC1 described often not knowing what SC1 ate: "I don't always know what he is eating throughout the day. I only know what he is having when he is with me, and see in that, he is willingly putting in what he is eating. So yeah I enjoy that, I like that" (M4). Having greater awareness decreased their uncertainty of what the secondary caregivers were eating, creating greater peace of mind. This was best exemplified by PC3, who had repeatedly described worrying about what SC3 ate at school or when she was not around. However, after using the application for four weeks, she described feeling less uncertain about SC3's eating behaviors and sense of control over the issue: "I know she's not like, eating stuff, like if I have the non-*<pause>*, the less healthy stuff in the house, I know she's not eating that, she's eating stuff that I would prefer her to eat" (M4).

Secondly, having an increased family snacking awareness prompted primary caregivers to prepare snacks ahead of time for their children and purchase healthier foods for the home.

For example, PC4, who was a mother of four and worked full-time, mentioned that the awareness of her children's eating habits motivated her to plan meals to ensure they were eating healthy: "It is useful because then I can view my kids' snacks if they are not eating healthy at school. Or view what they are putting in because maybe then I can have something planned out where they make sure they go to school with something I know they are going to eat" (M4). Primary caregivers discussed purchasing healthier foods, especially fruits, more often when they were at the grocery store. PC2 described how she used the suggestions from the application to purchase fruits "instead of candies or cookies". We also found an increase in the self-reported, post-intervention availability of fruits that the intervention group had in their homes compared to the control group that approached significance, $F(1,17)=3.42$, $p=.082$, suggesting that the intervention group participants either purchased more fruits or became more aware of the fruit they had in their home.

For secondary caregivers, family awareness provided three benefits: 1) it motivated them to eat healthier; 2) gave them new ideas of foods to eat; and 3) provided opportunities to compare their performance with their parents. Secondary caregivers described an increased motivation to eat healthier that came from a greater awareness of their parents' snacking behaviors. When they were aware that their parents ate healthy, they wanted to improve their own behaviors. SC4 described how seeing her mothers' healthy eating motivated her: "I don't really eat healthy and I noticed that my mom does, so I'm like 'maybe I should eat more healthy' cus I think its better to eat healthier like now since I'm younger so it becomes a habit when I'm older" (SC4, M3).

Secondary caregivers identified new snack ideas through an increased awareness of the primary caregivers' behaviors. Some of these ideas came directly through the application as several secondary caregivers looked at the primary caregivers' phones to see the snacks that they were eating for new snack ideas: "Yeah, and like, I see what she's eating, and I'm like, 'hm...maybe I should have some.' But if its gross, I'm like 'no thank you'" (SC2, M3). Other ideas came from being more aware of what the primary caregivers were eating when they were together: "if mom were [eating] something healthy, like bananas, then I would be like, 'yeah! let's get bananas'" (SC3, M4).

Lastly, secondary caregivers repeatedly discussed how an increased awareness of their parents' behaviors helped them compare their own behavior with their parent. This was often in the context of the game, but also outside the game: "I see what she's doing and in mine it says she's [eating] healthier than me, so then I'm like 'oh crap' so then I really think about it and then I choose a healthy food over a fat food" (SC4, M3). Secondary caregivers described instances of when they would compare a snack choice they made with their primary caregiver's snack healthiness to get a sense of whether the snack was more or less healthy than what their primary caregiver was eating. SC3 compared her snack choices with her mother's snack healthiness level throughout the study. When she found that her mother was eating healthier, she internal-

ized a belief that she could eat healthier and would say to herself, *“oh wow, okay I think I can improve this”* (M4).

Although there were many benefits of increased family awareness of snacking behaviors, we also identified one example of a negative consequence. One family, PC5 and SC5, described tension that developed between them when they had a greater family awareness: *“I think I used like looking through the history and stuff because I like to see if I’m healthy or not ... and then I looked through my mom’s. But her’s is boring because it’s all healthy stuff ... I liked to pick out her mistakes. So if she is eating something wrong and she is yelling at me for eating wrong then I would say something”* (SC5, M4). In this case, SC5 would look at PC5’s phone to see the snacks that PC5 entered and used the information in a more oppositional way to defend her own behavior, however this led to dialogue around healthy eating. Both family members thought the increased dialogue was a benefit.

Honesty in reporting

Our findings highlight the importance of increasing family-level awareness through our application, which was, in part, driven by providing users with information about their family members. The utility of family behavior information, however depends on honest and consistent reporting from family members. Secondary caregivers did not raise concerns about their parents viewing the food they ate and said that they were truthful when using Snack Buddy. The only reason secondary caregivers cited for not entering a snack was because they “forgot it” (SC1, M3). We triangulated data from Snack Buddy snacking history with the 24-hour recalls to identify snack reporting accuracy. We found that only 5 out of a total of 31 snacks were not recorded in the application by secondary caregivers, but were reported on the 24-hour food recalls during M3 and M4. We did not find commonalities in the types of snacks that secondary caregivers did not report. They missed reporting both healthy and unhealthy snacks and neither type was less frequently reported. For example, SC2 recorded the cheeseburger she ate in the application, but not the healthier chicken sandwich. This suggests that secondary caregivers likely recorded the majority of their snacks in the application and did not underreport less healthy snacks. However, some primary caregivers, such as PC1 and PC5, held perceptions that the secondary caregivers may not have recorded all of their snacks: *“I don’t think he has been putting in everything in either, because when I go in and look there were days he didn’t put in what he was eating”* (PC1, M3). This negative perception, though inconsistent with our findings, may lead to distrust between family members or with the application.

Engaging non-users

Some participants mentioned that Snack Buddy improved family members’ health habits who did not use the application, which was an unexpected finding since we focused on facilitating interaction between the two application users in each family. PC2 described this change in her grandson: *“My grandson, I didn’t realize he was having unhealthy snacks either. So now we have gotten to the habit where we look at everything, like sugar content and stuff”* (M4). PC4 started

cooking a new, healthy meal once a week with her son, who was not a participant, after she saw all of the different foods in Snack Buddy. Although the effects of the application spread to other family members without them using it, primary caregivers wanted to have all of their children using Snack Buddy. When we asked PC2 if she wanted to have her other children use the application, she responded, *“That would be great, because we have our own snacks”* (M4). Secondary caregivers also supported the idea of including more family members in the application. SC4 described how, as the oldest child in the family, she would model healthier behaviors to her siblings and that this would also motivate her to eat healthier: *“they copy what I eat, so if I eat something healthy then they will follow me and eat something more healthy. So [I] choose the foods that are better for you, than foods that are not”* (M3).

Family members that were not using the application supported those that were using it. For SC4, her grandmother who was not part of the study, acted as a support system for application use and helped make sure she entered snacks when they were together: *“my grandma would tell me, ‘you need to put this snack in’ or ‘what have you eaten today? have you put it in?’”* (M4). PC2 got reminders from her youngest son about what snacks she had eaten throughout the day because she would occasionally forget what she ate. This was helpful to make sure she entered all her snacks and also engaged her son in self-monitoring and reflection. He would enter snacks for her when they were together if she was busy with something else, engaging him directly in application use.

Within-family competition

We found that our application facilitated within-family competition to maintain the highest average snack healthiness, get the most snack healthiness points, and progress through the game. Secondary caregivers expressed the greatest enthusiasm around the within-family competition, however the competition kept both primary and secondary caregivers engaged with the application, motivated them to eat healthier, and generated further dialogue.

Family members found the competition kept them using the application. Secondary caregivers found this aspect especially engaging and described how it kept them using the application and motivated them to use the application and enter their snacks: *“yeah, I use [it] a lot because ... it’ll say like how many points I have and how many points she has. I’ll be like - ‘ooo I got more than her’ and then when she has the same as me, I try to find a healthy snack to eat and then I’ll eat it and I’ll have more points”* (SC4, M3). Not only did the game keep them engaged, but the competition also served as a motivation to eat healthier. SC3 described how the competition motivated her to eat healthier: *“I think it helps motivate me to have more healthier snacks. Click on game mode, go to [my mom’s score] and say, ‘oh, dang mom, you’re ahead of me”* (M3). PC1 also felt like the competition would drive her to eat healthier, especially when her son brought it to her attention: *“the friendly competition thing where he would look at the stars and compare the stars and say, ‘oh, you are not eating as healthy as I am”* (M3).

The competition that took place in the application spilled over into participants' everyday lives and sparked further dialogue about healthy eating. PC3 and SC3 best exemplified the development of in-person dialogue around the competition and how it benefited their family. PC3 described the nature of the competition: *"It's like a competition, it seems like who's higher ... she can watch and she's like, 'you're ahead of me!' So I think it's kind of like a, a healthy competition going on"* (M3). PC3 and SC3 discussed how they would compare their snack healthiness, which created face-to-face dialogue where they would discuss their competition in person. After PC3 passed her daughter in points, SC3 asked her mother how she got ahead. PC3 provided a suggestion of a healthier snack that would help her do better in the competition: *"I told her that the almonds, she can eat as many as she wants and that those are one of the highest points"* (PC3, M3). Additionally, as a family, they showed the highest collective increase in family snacking awareness in the intervention group.

In our application, within-family competition was limited to the primary and secondary caregiver participating in each family. Both primary and secondary caregivers suggested that the competition would be even more effective with the entire family. For secondary caregivers, competing with their siblings was even more appealing than competing against their parents. When asked whether she would enjoy competing with her brother, SC5 responded, *"Yeah I think more so than with my mom"* (M4). Primary caregivers also echoed this sentiment and suggested competition within their children would be an effective strategy for healthy eating: *"It would be great, I don't know what it is with all my kids, but there is competition for everything ... I don't think it would get too intense. But I think it would probably get a lot healthier"* (PC2, M4).

Discussions about the application and healthy eating

Snack Buddy promoted discussion amongst family members about the application and healthy eating. As we previously discussed, PC3 and SC3 compared their points and healthiness stars at the end of the day when they were entering snacks. PC3 shared one of their interactions: *"I think at one point she did get ahead of me in points ... She thought it was so cool that she finally after like several weeks, finally got ahead of me"* (M4). PC4 and SC4 discussed the foods they entered into Snack Buddy and reminded each other to enter their snacks. They also reminded each other to eat healthy: *"and [mom will] remind me, oh we should eat healthier. And I'll actually be like, 'oh I need to!'"* (SC4, M3). It was also common for families to discuss their application use and remind each other to enter their snacks. PC1 and SC1 reminded each other to enter their snacks: *"I would just ask him, 'did you put in what you ate today?' or he might ask me the same question"* (PC1, M3). Discussions about entering snacks and application usage served as a launching pad for discussing what they ate and, more broadly, healthy eating.

Importance of culture in the family

In the interviews, participants discussed the importance and prevalence of foods that they associated with their ethnic culture, which differed from the dominant, white culture. PC2 described the prevalence of snacks they considered specific

to their culture: *"the snacks and candies and stuff that we eat that are different ... we have Tamarindo and chili and just, [cultural] snacks"* (M4). The importance of culture came up most when participants discussed a lack of cultural snacks in the database. Although we created a large database of snacks, it was difficult to develop a fully comprehensive database. Participants noted that missing snacks was the greatest difficulty with the application and this was especially true of food from non-dominant cultures, which was problematic since we worked with a diverse population: *"there's a lot of things that, like ethnic food that's not on there. Cus like, some of our snacks are like a lot different than like a bag of chips or a cookie or something. Like, I'll grab a taco, not like a taco bell taco, but like a fresh corn tortilla, meat, fresh salsa and stuff like that. And I'll just have one and that's like my snack"* (PC2, M3). PC2's quote highlights that even the conceptualization of what constitutes a snack can differ across cultures. The idea of a snack for one vietnamese family included drinks like tea and vietnamese coffee, while the latino/a and chicano/a families considered smaller versions of meals, like tacos or menudo soup, their snacks.

Missing cultural foods was frustrating for participants and made them feel marginalized by the application; like the foods that they ate were not valid snacks. SC2 described her frustration with the lack of cultural foods: *"My mom makes menudo and it wasn't in there. We eat mexican food a lot and they didn't have them in there ... it was just kind of hard to see that because we couldn't get points for those. It was like, 'oh well, I should have ate something else'"* (M4). Other participants talked about how they would often not input a snack because it was missing from the database or would work around the problem by entering a snack that they felt was similar in healthiness. The issue of missing cultural foods in the application was representative of the broader issue of cultural identity within the family and its interplay with our application. For participants, missing these snacks was more than an issue of not having comprehensive choices available for snack entry. They framed it as an issue of their culture and identity, reinforcing the need to consider non-dominant cultures in all aspects of our application.

DISCUSSION

Overall, participants responded enthusiastically to our application and had positive experiences. Participants appreciated the ability to receive feedback on snack healthiness, review their snack history, see family snacking information, and get reasonable snack suggestions. Although we found a decrease in the number of snacks entered over the four weeks, participants were still engaged at the end of the study – using the application almost daily. We attribute participants' positive response and continued use, in part, to providing different user experiences that met the distinct needs of primary and secondary caregivers and engaged the entire family.

The participants focused on the family aspects of the application and highlighted the importance of including the family. Researchers in the HCI-field have developed health behavior interventions targeted towards adolescents [9, 40] and adults [14, 18], however there have been few efforts to facili-

tate family-wide initiatives to improve health [12]. Our findings support the idea that targeting the entire family with an intervention could be a powerful strategy to support healthier behaviors. Participants described countless examples where Snack Buddy affected them at the family-level, such as PC3 and SC3 who would tease each other about their competition and encourage each other to input their snacks. These results bolster a body of research, including a recent review of strategies to create healthy eating environments by Story et al. [39], that suggests a need to develop interventions that are deployed in the home and target the family, an important factor in behavior. In the following sections we discuss benefits and challenges with developing family-level health interventions, along with strategies for designing future sociotechnical interventions for the family.

Benefits of family-level interventions

We identified five benefits of family-level interventions – 1) facilitating family support of healthy eating; 2) facilitating family support of application use; 3) increasing family awareness of behaviors; 4) restructuring the home environment; and 5) engaging the cultural and shared values of the family.

Support of healthy eating: Previous research has found that families often do not discuss health issues, especially if those dialogues cause distress about the consequences of health behaviors [6, 22], yet family social support is important in behavior change [21]. By targeting the family, our application facilitated support between family members in working towards healthier snacking. Family members encouraged each other to eat healthier snacks and had dialogue around healthy eating and snack ideas outside the application. They had conversations on topics ranging from the nutritional labels on food to what snacks were the healthiest. Participants also sent messages through the application encouraging healthy eating, though primarily at the beginning of the study. Our research suggests that family interventions can create opportunities for positive dialogue around health and prompt family members to provide social support for each other, which they may not normally do in their everyday lives [22].

Support of application use: Much like with healthy eating, we found that family members supported each other in the continued use of the application. They reminded each other to enter their snacks and use the application on a consistent basis. Reminders were provided during in-person conversations as well as through the messaging feature. They also indirectly motivated each other to use the application through their competition and positive encouragement of healthy eating. Our results suggest that family-level programs may keep users engaged with interventions for longer periods of time and to greater extents by creating environments where family members support application use. However, more work must be done to directly compare engagement in family versus individual interventions.

Increased family awareness: Previous research has identified personal awareness of behaviors as an important component in behavior change [14, 41]. In our research, we identified family awareness of health behaviors as a related and important concept. Our research revealed that family aware-

ness was very similar to the broader concept of ‘social awareness’ – individuals’ ability to recognize and understand the activities of others and how their own behaviors relate to others [36] – but focused on the family. This awareness of the family members’ eating behaviors aided in their collaborative work towards improving their individual eating practices and the practices of the family as a whole. Similar to previous findings around awareness as a collaborative practice, family awareness allowed family members to pick up on the actions of others and adjust their own behaviors and beliefs accordingly [37]. As primary caregivers gained awareness of the secondary caregivers behaviors, they were able to adapt their own practices, such as packing healthier snacks, to continue their work towards improved family health. For secondary caregivers, family awareness helped them adopt new eating practices and also develop new beliefs and perceptions around healthy eating. Secondary caregivers described feeling more confident in their own ability to eat healthier and having a more positive attitude towards healthy eating after seeing that their parents model those behaviors. This is consistent with previous research, which highlighted family behavior modeling as an important component of family-based interventions [19, 21]. Family interventions provide the opportunity to facilitate healthy behavior modeling through increased family awareness of eating practices, not only for primary caregivers, but also for secondary caregivers, who can model healthy behaviors for their siblings and peers.

Previous CSCW research on social awareness in health has focused on creating and studying virtual spaces for people to develop an awareness of others’ behaviors [8, 17]. Our findings suggest that family awareness of health behaviors is driven largely by and benefits in-person interactions, more so than virtual interactions, because family members typically see each other daily. Features that facilitated direct virtual interactions, such as messaging, were described as not useful, whereas features that enhanced in-person interactions, like the competitive game and family snack history, generated positive feedback from families and provided them with information that they could use during in-person interactions. When working at the family-level, the focus should be on providing awareness information that empowers family members to better engage with each other in their everyday lives, outside of the application.

Restructuring the home environment: Our research also suggests that engaging the family with an intervention may support change in the home environment – a factor that has a significant effect on family behavior [39]. The home environment affects the snacks that are available, the meals that family members eat, how much they eat, and the food preferences that children develop [21]. We found that purchasing groceries was a family activity for many families, so having multiple family members advocating for healthier purchases may help increase the availability of healthier snacks, such as fruit. Increased availability of healthy foods would in turn improve the likelihood that families would eat healthier items. In addition, we found that family members noticed healthier options in their environment and brought those items with them to work and school. Conversations around healthy eat-

ing in the home meant that participants and their family members were exposed to the healthy food dialogue more often, likely increasing their preference for healthy foods [21].

Supporting culture: A final benefit that we found was engaging the culture and shared values of families. The families we worked with shared their culture within the family and identified it as a source of pride. Culture played a role in their ability to engage with the application and in their foods choices, an effect documented in previous research [30]. We did not provide a comprehensive list of culturally relevant snacks in our application, which made it more difficult for users to engage. Recognizing this limitation with our application and the effects it had on participants highlights the importance of culture and suggests inclusivity of families' cultures would be an opportunity to improve intervention engagement. Working at the family-level provides a chance to better support users' culture because it is shared among family.

Challenges with family-level interventions

Although there are benefits working at the family-level, the approach is not without significant challenges. These challenges include: 1) working with the unique dynamics of different families; 2) managing privacy and conflict within the family; 3) supporting accurate and honest reporting; and 4) engaging all family members, who are different ages and have differing family responsibilities.

Unique family dynamics: As we found in our study, families had different dynamics that manifested during application use. For some of the families, having the detailed snacking information was a major benefit and supported modeling of healthy behaviors. For other families, the family snacking information created a source of conflict and aggressive competition. Some families rarely discussed the application or healthy eating during the intervention period, while others consistently had in-person conversations about healthy eating. Families also identified with different cultures that had unique foods, traditions, and social dynamics, which, when not considered, can lead users' to feel frustrated and disenfranchised. These differences in family dynamics, and the way that they manifest through application use, make it difficult to create mobile interventions that work for every family.

Privacy and conflict: The need for users to have both transparency and privacy within their family presents a significant challenge and captures the key design tension of privacy in supporting awareness in collaborative systems [20]. Primary caregivers gained significant benefits from seeing the detailed information for their whole family, however this undermined secondary caregivers privacy and autonomy, though they did not express major concerns around this. Additionally, families identified benefits for secondary caregivers if they had more information on family behaviors, however this would limit the privacy of primary caregivers and potentially shift dynamics within the family. Care must be taken to protect family dynamics because, as we found with one family, PC5 and SC5, a lack of privacy can create conflict between family members, which could endanger engagement with the intervention and potentially cause harm to the family. Although

both family members responded positively to the application and enjoyed the competition, long-term use and continual conflict may cause damage to the relationships within the family and make positive behavior change more difficult. This can be especially problematic when the information and privacy controls provided allow users to undermine their family members' autonomy or exert social control over their behaviors [42].

Schmidt poses a question when considering information transparency in social awareness systems to help address the tension with privacy – “upon what evidence does an actor rely when heeding the activities of others?” [37]. In this case, family members do not need full transparency of their eating practices to develop awareness that facilitates their desired outcomes, however they do have important awareness needs that systems must address. Understanding these needs informs the types of awareness information necessary and the extent to which privacy can be provided. For primary caregivers, there are two key needs to be addressed – 1) providing peace of mind around the kinds of foods their children eat and 2) providing actionable information that allows them to take action to improve the eating habits of their family. This could be accomplished with an approach that balances privacy and awareness. For example, P3 wanted to know that her child was not eating a significant number of unhealthy snacks, something that could be captured in an alert directing the primary caregivers attention to the fact that their child had several unhealthy snacks. Secondary caregivers had different needs that included 1) learning that healthier eating is achievable; 2) developing a positive attitude towards healthy eating, and 3) identifying what practices they can adopt to achieve those goals. Awareness systems for the family should be designed to meet these identified needs for both types of family members with the greatest privacy possible.

Honest reporting: Another challenge is ensuring accurate and honest reporting of data. The secondary caregivers emphasized that they reliably entered their snacks, which we confirmed with the 24-hour food recalls, and did not express concerns about having primary caregivers reviewing their information. However, several primary caregivers expressed uncertainty around whether the information was accurate and suggested that they would be cautious to interpret the data. It is important, with a family intervention, to facilitate honest reporting and create confidence among family members in the integrity of self-recorded information.

Different family members: Creating components that engage and impact all family members presents another difficult task. We found that primary and secondary caregivers engaged with different features of the application and diverged in the aspects of the application that they found most valuable. Primary caregivers emphasized the importance of the family aspects of the application, specifically the ability to see what their children were eating and the overall family snack healthiness measure. They viewed the application as an opportunity to make their entire family healthier and focused on the overall healthiness of their diet. The secondary caregivers were more focused on how the application affected them as

an individual and compared their own performance with the primary caregivers. They primarily focused on their progression through the game, the competition, and making specific changes to their diet.

Strategies to engage the family in healthy eating

We believe that demographic-targeted interfaces present one strategy to fill the gap to engaging the entire family towards healthy behaviors. These types of interfaces provide a single underlying framework that enables family members to collaborate, share, reflect, and compete, while displaying information in different ways that are engaging to family members of different ages and with different responsibilities. Participants used the interface that was designed for them throughout the study – primary caregivers used the informational interface and secondary caregivers used the gaming interface – even though they tried both interfaces. Secondary caregivers explicitly told us that being able to progress through the game kept them engaged and striving to eat healthier. Primary caregivers, on the other hand, preferred the informational interface and voiced a dislike of the gaming interface.

Increasing the transparency of family behaviors – allowing family members to see information about the health behaviors of others – for all members of the family would help facilitate family awareness and learning. Increasing the availability of information is important for a family-level intervention because family members can influence each other with their behaviors in a reciprocal way [21]. When secondary caregivers looked at the application on their parents' phones or had discussions about healthy eating, they described learning about specific snacks or behaviors to adopt. Our system made this sharing more difficult because secondary caregivers could not use their phone to see the primary caregiver's detailed snack history. Because the participants highlighted the value of sharing this level of detail, we believe that there is a need to allow both primary and secondary caregivers to share details about their snacking behaviors and have transparency of family behavior. However, this information can be used in a negative way, especially when it enables people to exert social control over others [42].

Our research suggests that having both 'family space' and 'private space' in family applications is one route to achieve a balance of privacy and transparency. This would provide mechanisms, as suggested by previous work [11], by which family members can have their own space within the application and control their sharing to some extent. A 'private space' would provide a safe space for users to honestly report their behaviors and allow users to personally reflect on that information [11]. The 'family space' would provide an open forum for sharing health behaviors and facilitating shared reflection and dialogue. Family members could actively decide to share certain foods or behaviors into the 'family space' that they felt comfortable sharing with the rest of their family. This, however, presents a challenge in that increasing privacy will decrease the transparency of information available to family members, likely slowing the development of family awareness [20], which we saw with the secondary caregivers who had less access to primary caregivers information. In

this case, some information may be shared automatically in an abstract or aggregate way to ensure that the needs of all family members, as outlined in the privacy section above, are being met. For example, one might imagine how the 'family space' could consist of a stream of information containing highlights of family behaviors. The stream could provide a positive framing of unhealthy behaviors, such as suggesting to a primary caregiver that their child might need new ideas for healthy snacks because they ate a series of unhealthy snacks. This affords the secondary caregiver privacy around the details of what snacks they ate, while providing the primary caregiver with actionable information. However more work must be done to understand the extent to which different privacy and transparency configurations provide the desired outcomes for primary and secondary caregivers.

Within-family competition is another strategy that our research suggests is effective for engaging the family in behavior change. Although previous research suggested that families might respond poorly to within-family competition [19], we found that it was a major highlight for both primary and secondary caregivers. For secondary caregivers, this aspect of the application was the most exciting and what kept them most engaged in using the application. They also provided specific examples of how their competition with the primary caregiver led them to change their behavior such as choosing a healthier snack and increased their motivation to eat healthy snacks. Primary caregivers valued the competition, both because they enjoyed competing and also because it kept their children engaged. Because some research has suggested that some families view competition and direct comparison as negative and potential sources for discouragement [19], cooperation could be offered as an alternative mechanism to competition. Primary caregivers, as family decision-makers, could select which model of family interaction – competition, cooperation, or neither – best fit their family and the application could adapt the user experience for that mode.

The last strategy we identified for engaging the family was giving families the ability to create content in the application. In our application, giving the families the ability to not only create, but also rate the healthiness of new snacks would have helped ameliorate the problem of not having a comprehensive list of snacks. Family members could all contribute and provide feedback on proposed new snacks. Family members could also be empowered to create more content within the game to challenge themselves or others. This would help keep users, especially secondary caregivers, engaged with the application for on an on-going basis. However, more work needs to be done to develop processes and tools by which users can create and moderate family-generated content within the application.

LIMITATIONS

We recognize that we rely on self-reported eating data, which is a limitation in many eating behavior studies [5]. We triangulated several data sources – 24-hour recalls, PEIs, and snacks entered into the application – in an attempt to minimize the effect of this limitation. We also did not formally test any theory in our analysis, nor did we objectively test

for effects on underlying constructs, although our application was informed by theory. We did this because our research was formative and focused on understanding how participants used the application and the family interactions surrounding the application. However, exploring mediating factors, such as socio-structural support, is essential in understanding the effects of our intervention. Our future work will involve measuring key theoretical constructs, such as self-efficacy and social support, to test for effects of Snack Buddy on those constructs. Lastly, some of our results may not be generalizable because of our small sample size. Although we found meaningful application effects and compelling interactions within families, we will confirm and build upon these findings with a larger sample in the future.

CONCLUSION

In this work we used a mobile application, SnackBuddy, to explore the potential of family-level sociotechnical interventions for healthy snacking. The family plays an important role in determining health behaviors and our work highlights the potential of family-level interventions in promoting healthy eating. Our findings suggest that the concept of family awareness is distinct, but related to the broader concept of social awareness, and allowed family members to adapt their own behaviors to those of their family members, such as packing healthier snacks for someone who recently ate unhealthy snacks. Family awareness shares many of the same design tensions as social awareness – most salient in our work was the tension of greater awareness of family behaviors with the privacy and autonomy of individual family members. Strategies like public and private spaces and within-family competitive gaming can help address the challenges and design tensions that arise when working with the family, but more work needs to be done comparing the acceptability and effectiveness of different design approaches intended to bridge these tensions.

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